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CONVINCING DIFFERENT RISK CHARACTERISTIC INDIVIDUALS TO PROVIDE THEIR SOLAR PANEL ELECTRICITY GENERATION TO THE ELECTRICITY GRID

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ABSTRACT OF THE MASTER'S THESIS

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Abstract

Solar availability in Finland is abundant but the effective use by the public is minimal. This thesis is to go forth and explain the benefits of solar energy but also demonstrate the financial prospects for this venture. Due to the plethora of options of this subject can be explored, this thesis paper will observe individual's decisions with different risk characteristics. The decisions made by the different risk characteristics will be explained and how to motivate them to follow through a certain decision will be discussed. This will be done through theories and data that serve to enhance the decision making of these individuals.

An insight to some theories used is Choice theory, Game Theory, and Contract theory. These theories have been explored in different research papers separately and have done with extensive research. Taking from those examples and combing them in this thesis gives a better understanding into the decision making of an individual. Previous research papers are key as the knowledge gained will become the backbone of this thesis paper.

The point of this master thesis is to not provide a critical analysis on previous research papers but, to aid the progression of solar energy in Finland and suggest a potential solution that is found in these theories and data. This solution can help to increase the activity of solar panel as this type of energy is qualified for a pareto improvement.

Solar energy can play a crucial role in Finland, and it starts with the individual.

Keywords

Additional information

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1 INTRODUCTION

Renewable energy is a source to replace carbon energy sources. There are different classes of Renewable energy sources such as Biopower, Hydro, Wind, and Solar. The technology developed in recent years to convert such energies to electricity is truly astonishing. The implementation of these technologies is prevalent in many countries but keenly studying Finland. Hydro power has held the highest position of renewable energy that is used but Finland is qualified for Pareto improvement due to the fact, there are dynamic weather conditions the country experiences. As there is extensive research done about Wind energy and how it is a prevalent addition to the Finnish electricity pool. However, the focus is not on Wind energy but on Solar energy. Potential solar energy is being captured by the regular companies through solar farms but there is one bigger available source that is overlooked and that being personal homes.

The main topic here is to understand why individual are reluctant to invest into solar panels as they can increase solar energy production to make it viable in the electricity grid. Supplying to the electricity grid is good because the electricity price will be lower when renewables are used instead of carbon sources because renewables do not leave are larger carbon footprint compared to the carbon sources. There are cases of individuals installing solar panels in their homes, but the problem stems from why they are not readily offering their generation to the electricity grid. What is their cost-benefit analysis and is supplying to the electricity grid not financially beneficial to them or is there no social benefit they feel that is not being received?

This thesis aims to answer these questions, when the individuals supply to the electricity grid, this would yield a Pareto efficient outcome. As witnessed in the main questions in the previous paragraph, there is a lot if questions ask but these questions are the complementary as they will provide a better basis in convincing individuals to provide their solar generation to the grid.

The questions requires knowledge from previous research papers and the data they have used to answer their proposed questions. Some of the inferences drawn are going to be based on the tests that were completed during the time the referenced research paper was conducted. However, there will be independent research done with the analysis done on how much sunlight is available on average per month. The manipulation of the data is often hard to comprehend for Finland as the change is often drastic.

Different sections of this will help to gain a better understanding of what will happen. Starting with the background as to provide the general progression into renewables and how they have become very prevalent in the recent years. In this section the information gained will set a common ground of understanding. Then the literature review will provide what studies have been done prior and the conclusions that were drawn. Then look at the methodology for gathering data on the amount of sunlight each day in three different Finland areas. During this section, different theories will be referenced relating to Behavioural, Industrial, and Game Theory economics. The next section will contain the analysis of the data to the theories and make inferences which should guide to an understanding of the suggestions that will give later in the is section. After all these facts, the last section is the conclusion which will give a general overview of what was learned in mentioned sections.

2 BACKGROUND

Before moving forward, the emergence of renewable energy and the necessity of this source of electricity generation must be explained as the main topic is to evolve a small part of this expansive system. To understand how and why renewable energy is popular today, the past must be explained. Once the basics of how renewable energy is explained and their uses in the common day society. Then the link to Finland and break down the structure of Finland's electricity generation sources. From these subtopics, the motivation should become clearer.

2.1 The Beginning

Generation of Electricity was limited during the beginning, but the two main sources were coal and hydro. Coal was burned to produce steam that would turn the turbines to create electricity and this type of generation source would mutate to different sources of generation. The water wheel was the first to covert water into energy and it to power the lights in the home. The use of renewable energy was more prominent because using renewable sources was more than enough to compensate the everyday household. The demand for electricity was relatively low compared to today but that would soon change with the emergence of modernization. Which introduced new inventions that relied on electricity and renewable energy was not enough for the common household. The demand increased, so that would mean that supply had to increase, and one bountiful resource was coal.

Coal energy generation yielded both positive and negative consequences, but the goal back then was to use an abundant resource that would fulfil the electricity demand. The negative implication of coal generation was the slow inflicting damage to the environment, and this was not apparent in the beginning but as the years went on this would pose a threat. The use of renewables was available but was not significantly advanced so, they did not have a big role to play in the electricity market.

2.2 The Market

Generation of Electricity is a good that can be produced and distributed so, there is a market for the distribution of this good. Different countries have implemented their own way market but across the world, the concept remains the same. The basic premise of the electricity market is that an entity will generate the electricity and will sell it at the price listed in the market. This price is referred to as the spot price and whoever contributes to the market will get this price. The spot price is designed so, it can reflect the costs of the producer and can make a profit from selling to the market.

The supply can come from any source, renewable or carbon if the demand is met. If the market can make use of only renewable sources, then the prices will decrease as their operating costs are relatively lower compared to carbon sources. Spot prices are a good reference because it has two functions, it is the price that companies will get paid when they supply their generation sources but also, it is the price that individuals that use electricity must pay. Even though the individual is not paying as they are consuming the electricity but at the end of a certain period they will pay for the total amount.

The figure presented below gives a framework to what was explained previously. This graphic was taken from the Next company in Netherlands as they have gone into detail about the electricity market and the graph, they have presented is able to show how different energy sources contribute to the market. Also, gives an image of how low the prices can be if the demand was met with renewables. Since this thesis is to worry concerned about the Solar energy so, it is beneficial to pay attention to that section of the graph. In theory if more solar energy is available in market the spot price should decrease but to achieve that there are barriers. These barriers and potential solutions will be discussed later in this thesis.

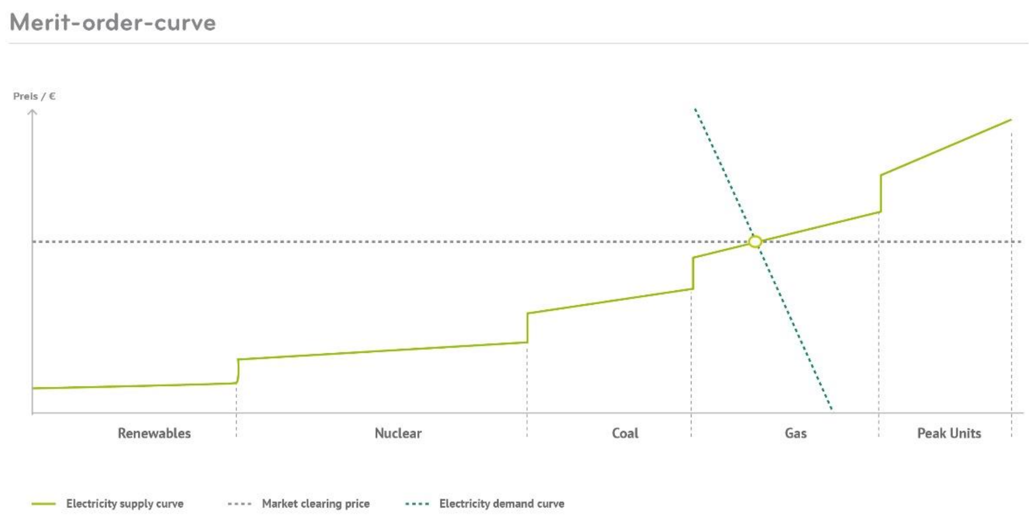


Figure 1: Electricity Market Curve (https://www.next-kraftwerke.be/en/knowledge-hub/merit-order-curve/)

If the spot price is too high then individuals can opt for a contract with a company to settle their prices so, there is no fluctuations. Individuals with these contracts will get electricity from the company distributors and the companies write a contract that will say that individuals must pay a fixed price per month for the use of electricity. There are also others, that personally monitor the electricity market and buy directly from the market. For those that opt for this technique of acquiring electricity, there is a technology that helps them maintain their usage of electricity. More recently individuals have been given more freedom on how they want to gather electricity, be it self-generation or using the electricity market. But there are other intricacies dealing with the electricity market but the keypoints are explained are statisfactory for this thesis paper.

2.3 Renewable Energy

From the first-time electricity generation was introduced there was the traditional coal-generated electricity but also, renewable generation in the form of hydro form. Renewable energy is defined as the use of natural resources commonly found on earth and can replenish on a time scale of human years. Carbon generation is the opposite of what renewable energy stands for because the replenishment rate for fossil fuels is roughly 10,000 years. Aside from the replenishment rate, the damage to the environment is significantly less from renewable sources compared to carbon sources. Often the effects are lasting when carbon sources are used for a generation whilst renewable sources come from nature itself so there is no significant problem as the output generated does not harm the environment or very minuscule . Within renewable energy sources, there are many but the main contributors to the electricity grid from most to least are usually Hydro, Wind, and Solar.

Hydroelectricity generation is the most consistent renewable energy group because the plant must be constructed with strong water flow to get the generation. As the pressure from the water turns the turbine within the system generates electricity. Some basic engineering knowledge is needed to truly understand how the system works. But hydro generation is among the first renewable energy to be used due to its simple nature of producing electricity. As mentioned before hydroelectricity constantly contributes to the electricity grid because the water flow is not disturbed so, this type of renewable energy is often relied on.

Wind electricity generation is tightly correlated to the wind factor of the area as the airflow is the major cause of this generation. The general structure of wind energy is broken down into installations of turbines and as the wind blows, electricity is generated with the rotation of blades. Wind turbines are best located where the wind is frequent, such as hills and on. Wind energy can outpace Hydro generation if and only if there is a strong wind blowing. So, wind energy is a strong contender against hydro energy, but the next renewable energy talked about almost always performs low compared to mentioned energies.

Last renewable source to be discussed is Solar energy, since this energy source is the main topic of this thesis paper. Introduction to this source is crucial in understanding as rest of the thesis revolves the knowledge of solar panels and the benefits it can result. This benefit will be crucial in getting to the individuals to see what they are missing and explaining how they can gain from this.

Solar panels can be best to explained when simplified because the technology behind solar panels is complicated. But the core function of solar panels is to capture the rays from the sunlight and converts that to electricity. When those solar panels capture the rays and is transformed electricity, that electricity is directly used for the needs of the household. Depending on the usage of the electricity taken from the solar panels, there can be surplus and that can be supplied to the electricity grid. However, if the individual wants to supply it to the electricity grid, then there are some decisions that must be made. They need to observe how much the price the company is willing to set compared to the individual's ideal price. In case the individual chooses to give the solar panel generated energy to the electricity grid, the price the individual pay for the electricity is less than the price they receive for providing their energy. Essentially the individual should be able to make a profit from this venture and end up paying more as they ideally want to reduce their electricity bill. This cost/benefit analysis has been recognized and not been discredited but in order to incorporate this analysis into the working model would yield over complication. Hence this thesis is focused is on the individual risk behaviour choices. But as this thesis progresses these topics of choice and costs will become more apparent as those specific topics are introduced.

Moreover, the certain costs for installing these solar panels are fixed costs because these panels are placed in a manner where they are pointed towards a certain angle as there is no dynamic shifting where the sun shines at points that all these panels will reach their efficiency. However, this type of source often contributes less to the electricity grid even with a high absorption rate because the costs associated with installing and maintaining it are relatively higher when compared with other sources mentioned here. With other sources mentioned here, there is a constant source without interruption, but solar energy suffers from that because there are a lot of variables to be observed whilst the rest are minimal. Some of these variables can be the clouds covering the sun or the solar panels being built in a location where they are unable to capture the sunlight properly.

Different countries lean on one renewable energy over the other due to many reasons but the main one being geographic location. Since the observations taken are local so, some preliminary information on Finland is required.

2.4 Finland

Finland's journey in electricity generation started with wood fuels after that a strong shift to hydroelectricity generation. The reason for starting with wood fuels is because Finland has a lush forest bed and can provide the resource to be used for electricity. Aside from the plethora of forest wood available the main renewable source that is abundant is hydro and Finland has taken the opportunity to increase the proportion of hydro supplying to the grid. This type of behaviour has increased in the recent decades, hydropower has been increasing but also, nuclear power is the main source.

Whereas wind power only supplies very little and solar energy is non-existent in the electricity grid but both are emerging only little by little. This is due to the numerous accessibility points to install hydro plants whereas, wind turbines are large and can usually be found in open fields with high amounts of wind which is hard if placed inland. But Finland has a large enough coastline that helps in turning those turbines so, a lot of the turbines are found there.

Solar panels are tricky because Finland has months that receive little to no sunlight and the placement is a decision that is not taken with full confidence by those that want to invest in them. When the sun shines during the summer there is a lot to capture and companies plus individuals can take advantage of this. Recently more companies and individuals are bearing the costs to install these solar panels. In recent years there has been a shift in where solar panels are installed. More and more personal homes are installing solar panels which are adding to the electricity grid in Finland. But some have installed are using it for self-consumption before selling their excess to the grid or even selling it, what might be the reason for this.

3 LITERATURE REVIEW

Many different research articles have explained the benefits and issues of solar power. Some have been outspoken about how solar energy is beneficial in Finland and made claims that radiations of the southern European countries are like those of Finland. Another paper installation process of the solar panel and costs associated with it. Also, how solar installations affect the price in the electricity grid. This type of paper is useful as it explores the specification and the effects of solar panels introduced. The data on residential solar panels is interesting to analyse as to what type of effect will have on residential homes. The above-discussed paper will explore thoroughly in the next few paragraphs, to fully encapsulate their findings and conclusion.

In "The role and opportunities for solar energy in Finland and Europe" (Hakkarainen et al., 2015) is about the benefits of using solar energy as a compatible electricity generation as there is abundant radiation. The researcher has discussed in their paper, the availability of radiation in Finland and how it is favourable to invest in solar panels. Also, drew on comparisons of how Finland has similar radiation and other countries with similar radiation can use it to convert it to solar energy, which then supplies the grid. The researchers conducted forecasting of solar and wind production to observe what would happen to the electricity grid. During this forecasting, the researchers had to analyse some of the issues of forecasting with solar and wind. The issues regarding solar production forecasting were due to the complexity of observing the data relevant to solar radiance. There was no quick method of getting the dataset and even if acquired there were many variables that affected the radiation. To count the change in the forecasting model would be difficult as there is a constant variable to depend on to create a proper model. However, a model was performed but with only a certainty of six hours, but this forecast was accurate enough for the researchers to conclude about the future. The result of this forecast sets a strong foundation for understanding the complexities of solar energy production and the possible solution.

The paper "Residential solar power with thermal energy and carbon-corrected electricity" (Huuki, Karhinen, Böök, Ding, & Ruokamo, 2021) explores many questions relating to solar energy and how it affects the electricity market. This paper has added value to how solar energy can be used in the electricity market and how profitable it can be. To begin with, the researcher must figure out how much solar power per hour can be generated and they must use water heating in residential homes as the reference point. To get the specific data on water heating, the researcher narrowed their geographic location to three areas by acquiring data from "Finnish Energy,2020". Through rigorous equations to acquire the usage of water heaters, they were able to calculate how much solar power was able to be produced. With knowledge equipped, the researchers were able to take a model that was prebuilt to give a rough approximation of how much solar generation can be generated at a specific location by metrological observation. After all this preparation the researchers were able to plant solar panels and explain the costs of installing such instruments and the economic analysis of the installation of these panels. The costs were heavily tied to the bidding rate in the public market and the winning bid is the price of the cost of panels. Hence these costs are dynamic to how the electricity market is performing. After the testing, the researchers proceed to conclude the fact that profitability in a residential home is exaggerated near the Arctic Circle as there are discrepancies with the residential homes' consumption of electricity to solar power output, but the researchers made a keen observation that the electricity market is relying on consumers to contribute to the grid. The method performed by the researchers to observe, and the conclusions drawn are helpful for this paper as there is a clear understanding that the electricity grid trying to rely on the consumers to contribute to the grid and there is profitability in this venture for the consumer. But moreover, the possibility of more solar energy provided by residential homes is interesting to know and the knowledge gained by the conclusion sheds light on the costs of solar panels.

4 METHODOLOGY

4.1 Introduction

Since this thesis mainly focuses on the decision-making of the individual, not a lot of data is required. As the focus is based on the theories and the application of the theory to different policies that can help better the individuals' decision to contribute to the grid. However, any data used here is directly related to the observation of solar radiation and the changes from previous years to the current year. The practice of forecasting for solar radiation would yield mixed results as different factors need to accounted for and if a forecast was projected, the results would only show for the short term with a small R^2. Hence, there is no forecast presented and even though such a forecast would aid in the decision process. Aside from the data presentation, the focus of this section is on the theories that can help to understand why individuals are not installing solar panels or selling their generated energy.

This section is comprised as such, theories will be introduced first to see what economic framework the data will work under and then introduce the data which show the solar cycles in the different regions of Finland.

4.2 Theory

Individual choice is prevalent and crucial to understand what how these choices formulated hence, studying choice theory will be useful here. Using Game theory as a framework will provide the direction an individual choice path would theoretically take. This type of progression is done through game trees as potential choices are presented to the individuals. In addition, industrial economics must be brought here to understand the constraints the individuals are dealing with as they are in a business setting and following a certain model will give context to the conditions they are operating under. Also, there are other businesses like the electricity distributors that partake in these business activities and the same model can be used to explain their actions.

4.2.1 Choice theory

Choice theory was first founded in Psychology as it was a way to explain how individuals would make their decision given their situation and the choices presented to them. Since some of the theories are direct derivations from psychology to economics. The main difference between choice theory in these two fields is the application of the theory, psychology theoretically explains the theory and so does economics, but mathematics is involved. Mathematically this is explained by taking the choices the individuals have the access to and checking the preference, which is usually seen as a probability, for each choice. The choice would have been associated with a number and taking that number to calculate the optimal choice for that individual. Another topic that can be considered here is the risk behaviour of the individual as having different risk behaviours can affect their choice even though a specific choice is beneficial.

Risk preference can affect the choice selection of the individual and taking time to understand this topic will provide to be fruitful. This information will aid the decision-making process of the individual and will lead to a better understanding of why individuals will choose to withhold than sell their generation to the grid. There are three types of risk: Risk-taking, Risk-neutral, and Risk aversion. Starting with risk-taking, this type of behaviour is simplified to the act of always taking the bet if given the chance and this type of behaviour does not perceive the dangers of losing too much. However, the opposite of risk-taking is risk-averse, this is where the individual will not take the bet and always choose to play the safe option if given. The balance between these two risk characteristics is risk-neutral, where the individual is indifferent to the choice in front of them. These types of individuals are more carefree than the other risk characteristics and are not bothered if there is a gain or a loss on their investment. Due to the dynamic nature of individuals, this paper's focus shall be placed on risk-taking and risk-averse individuals.

Two research papers should help to understand risk and the connection with rational choice theory. Some of the papers presented here borrow literature from Psychology as there is clarity in the analysis compared to Economics. The first paper will be about the topic of Risk itself under the science of Psychology and Economics, then the next paper is about Rational choice and how risk behaviour changes throughout the individual's age. Once these papers have been presented a better sense of why these theories are important to the topic of the paper.

Starting with the first paper, the general premise the researcher establishes here is that risk has often lacked the empirical side and makes the study of risk "… to be a weak hypothesis …"(Arrow, 1982, pg. 1). "Risk Perception in Psychology and Economics" (Arrow, 1982) is the paper that Arrow uses to explain the different changes in risk and how it has evolved from its first revelation. The concept of risk in psychology is studied more in cognitive psychology and the concepts found there are translated to economics. Risk in economics is linked with the rationality choice-making assumption and how rationality is often altered when faced with a decision. However, when making the decision it is common to figure out the entire possible information and Arrow addresses that an individual gives priority to recent information compared to much older information. "The individual judges the likelihood of a future event by the similarity of the present evidence on it. There is a tendency to ignore both prior information, … and the quality of the present evidence …" (Arrow, 1982, pg. 9). This type of phenomenon was figured out in psychology as psychologists were able to run studies on how individuals would base their decision-making. If an individual can base their decision on previous actions, the future is still a mystery as no one can predict that with full certainty hence, there is risk in taking the decision. The application of risk is thoroughly explained by Arrow and the main key point here is that a rational individual decision-maker will not always be profitable due to the uncertainty of the future and all a rational individual is all done in the short term. Arrow's paper has complied with different topics of risk and the choice the individuals will take depending on the risk behaviour. Psychology helped that paper to give an insight into how individuals make their decisions and what biases are formed before making the decision. Also, how individuals tend to ignore key information in the future and gain a tunnel vision mindset in gathering their information. This directly relates to the topic of this thesis by the individuals are more likely to gain this tunnel vision mindset in why they might decide not to sell their generated electricity to the grid.

The next research paper is about risk and how different age groups have different associations with risk. "Risk Taking Across the Life Span: A Comparison of

Self-Report and Behavioural Measures of Risk Taking"(Mamerow, Frey, & Mata, 2016) main objective to figure out is, how an individual will change their characteristics as they grow up. To measure this, a cross-section study was used to look at the different age groups with the similar experiences in their life. One of the testing methods for riskiness is to administer a test that lets an individual decide on a bet and present the results to find the risk behaviours among different ages. The incentive used to motivate the individuals to do this study is money. Doing different tasks would also yield money as well and this was useful in determining the risk as the individuals can gamble their money if wanted. Once all the tests were administered the authors were able to use regression analysis to observe how age factor influences risk. "Sex and age were not a significantly predictive of choosing the risker option…" (Mamerow, Frey, & Mata, 2016, pg. 18) which was the result of one of the tests that were administered. Then interpreted the results but other results are not as mentioned here as to only focus on only some of deciding factors. In the conclusion of the paper, the researcher concluded that "All three measures yielded *some* evidence for reduced risk taking with increased age…" (Mamerow, Frey, & Mata, 2016, pg. 22). As age increases the willingness to take risks goes down thus making the individual risk-averse and the application of such a topic can be used in determining the risk level of choosing not to sell the generated electricity to the grid. Such a topic is used heavily in deciding the contract which is after the next topic.

Risk does play a key role in each individual's life as they have to choose a certain topic and that choice carries a certain level of risk. Depending on the individual's risk characteristic they will act differently to the individual next to them. The first paper referred here can explain the conscientious choice of ignoring information about the choice the individual will make. Also, if an individual can collect all the information for a choice they would not be able to make an efficient choice as there is no possible way of predicting the future with pure certainty. So, risk preferences of the individuals will affect their choices on the information they can gather but the second paper referred suggests that the age factor tends to play a role in the risk preference an individual will have. As an individual grows up, their risk preference tends to decrease and this is further proved by the numerous test that was done in the paper. These two papers have defined the risk and choice theory, which will prove to be useful when this theory is referred to in the future sections of this paper. Once the choice is made and if an external party does not understand how the choice flourished. Game theory is there to clear the confusion as there are game trees that can provide the line to that choice. Which is the next topic that will be discussed.

4.2.2 Game Theory

There are many great topics within Game Theory and useful models that can try to explain the individual choice theory. However, the main model to deal with is the game trees. As game trees will give a visual representation of what the individuals are choosing and what the potential payoffs could result. A better picture can be painted with how individuals are comparing the benefits and costs. Once game trees are made the ease of drawing precise conclusions of an individual will become easier.

The basics of Game trees are essentially broken down into branches and nodes. Taking a simple game tree should be suitable to explain the concept so, that two players have two options and the catch here is that both players are not going to pick at the same time but rather one after each other. The player who chooses second will base their choice after the first player. This is crucial because the second will choose the option that gives them a better payoff. For example, there are players 1 and 2 who are going to choose either a crate of apples or a crate of oranges. Following what was said previously, player 1 will choose the crate that gives them the highest satisfaction and player 2 will choose the crate that gives them the highest satisfaction; at the end, the payoff for each player will be given. Of course, there are ways that a player can offset the game if they have information about the second player and play to the choice that would yield a higher payoff than before. But such topics will not be touched on because the main use of game trees is to understand the decision-making of the individuals on the topic of self-generated solar electricity. There are different published papers that have used game theory and game trees for their models. Following their example with assist in creating a game tree with their guidance and how they were able to extrapolate data for their analysis. Once each player had selected their choices and look at the game was play, you can see the decisions the players took. This overview will become useful in later sections.

Many research articles have been published that explain Game Theory and how the models within are in effect in the electricity market, here is one research paper that explain implementing the models practically. Dermot Gately published "Sharing the Gains from Regional Cooperation: A Game Theoretic Application to Planning Investment in Electric Power" (Gately, 1974), where he was attempting to get three different states in India to cooperate so they can spread the power generated. Gately uses game theory to provide a possible solution where Pareto optimal can be reached within the three states. As Gately looks at the different models of Cournot, Oligopoly, Monopoly, and such, he states "… the gains from cooperation are always positive, there is always one area in which greater costs are incurred under cooperation than under self-sufficiency…"(Gately, 1974, pg. 9). This statement is useful to understand how the game application can be employed when discussing energy issues.

The different models found within game theory were alluded to in the previous paragraph and they are all useful in understanding how different firms will act. However, when coming to the electricity market, most of the firms are working under a natural monopoly. This is due to the necessity of electricity required by the populace. Game theory is involved in this by the natural competition amongst different firms that will provide to the grid for a given price. Some countries may participate in these natural monopoly practices but, there are countries like Finland that promote different companies to partake in the business and create a competitive market. Regardless of how each country sets their status for the industry, almost all of them are following the same structure with the pre-text of game theory as their driving economic theory.

In practice, there are different energy firms found in Finland and other Scandinavian countries. This is further explained in the "A game theoretic model of the North-western European electricity market-market power and the environment" (Lise et al., 2006), where the researchers observe 8 different countries and how each country exercises market power. That paper's main conclusion wishes to draw upon the effect of market power use and the effects it has on the environment. The use of this paper is to understand the market structure that Finland's energy companies operate under. Even though the referenced paper was published in 2006, the structure is quite like the current day and maybe some policies have affected the structure, but the core is still the same. Aside from observing the structure of the market, the paper provides provoking thoughts on how to diversify energy generation to achieve lower prices for the customers. The model the researchers use in this paper is "The electricity Market liberalisation in Europe (EMELIE) model … is an extended version of the original model applied to the German electricity market in Kemfret (1999)…" (Lise et al., 2006, pg. 2124). The application of this model further explains the game theory principles of the different market structures and since the conditions that firms were observed in structured around an oligopoly. The model used gives the researchers an understanding of how much amount a firm would pursue or evade the choice. This allows the researchers to create a game tree with different branches that show the financial amounts the firms would be willing to take. These financial amounts are mainly marginal costs, and the researchers take their time explaining marginal costs are a key factor in the market. Also, how the firms would react if the market conditions had changed to some other market. Regardless, the researchers reiterated how game trees are useful and the importance of how different markets affect the decisions of firms participating.

Game theory is broken into finding the players to which market they are operating under and following the game the players by making a game tree to observe the choices made before. Once the structure has been established it is often crucial to see how each firm in the market will collaborate and what cooperation agreement will be beneficial for each other. This cooperation was shown precisely by Gates (1947) with different states agreeing with each other and the agreement that was made benefited each state. Since each country in the world is very specific in the market structure for electricity and different issues can arise from such issues. One of the issues is the abuse of market power and which would lead to negative outcome consequences. To explain further Lise (2006) was able to approach the situation and apply the game theory model. The practicalities of a game theory are observed through this paper as he was to figure out why the firms in the market would evade or continue with their practices in the market. Game trees can streamline information and help to understand the decisions the firms are making hence, making them a key component in understanding the decision of the individuals for solar panels generation.

4.2.3 Contract theory

Contract theory stems from industrial organization economics as it is a form for companies to legally agree to the terms and conditions of a business deal. This theory takes aspects from choice theory, risk, and Game theory. This theory refines the broad prospect of the other theories but, to understand contract theory; Industrial economics needs to be mentioned as it is base. Once industrial economics has been introduced then two different papers will be addressed here to give a unique perspective into contract theory. One of these two papers compares how contract theory is observed in law and economics while the second paper questions the risk preferences of an economic contract. These two papers will help this paper provide a possible solution to the electricity contribution that has been generated by individuals.

Industrial economics is the study of examining firms in different markets and observing the interaction between the firms and the market it operates under. Study the firms, various theories are used to study the decision process of the firms. Game theory is a big factor in industrial economics as the study observes the moves of each firm and there an only theory that can competently provide such results is game theory. Game theory was explained in the previous section, even though the topic was very specific the main point from that can be applied across the theory. Taking the knowledge gained from the game theory and was applied to a firm then would essentially make up industrial economics or the general sense of it. Almost all the complicated theories found in industrial economics are a direct derivation of game theory in some way or another. The complicated theory would be contract theory which has a scientific field that truly dedicates itself to understanding this theory and using the theory to work on this field's behalf; This field of study is Law. Law contract theory is the base for everything that stems from there but whereas economics use contract theory in a fashion to explain the legal agreement between two different actors. Since this paper is based on economics, henceforth the perception of contract theory is to be seen through an economic lens. That is the core economic value of efficiency and the interaction of two different actors. In industrial economics, contract theory is the agreement between two firms and how the conditions that each firm must agree to but also uphold their end of the deal. If one firm decides to break from the contractual agreement, then there will be punishments for such deterrence. This idea can be applied to the personal individuals as well because when a contract is signed, they must stick to those parameters. But when it comes to personal individuals there is the risk factor, and this is true for the firms but more observable in an individual. Within contracts there can be complete or incomplete contracts, the latter is more common. The basic definition of a complete contract is the ability to judge everything situation and give a proper response to it but that is often not the case as no one can with fully certainty predict the future. So, the most common contracts are the incomplete contracts where they list out the most common situations and what the proper action is to be taken. With these differing contracts, certain questions will raise about efficiency and what the risks are taking on such a contract. The following research papers will explain each of those topics deeply to understand.

The research paper connects risk and contracts by applying them to the farmer's work. "Risk Preferences and the Economics of Contracts"(Allen & Lueck, 1995) is the paper that has shown the connection between the two topics and how interrelated both they are in a farmer's life when making a contract. To provide context, the farm can be seen as a risky venture because the outcome of the corps is reliant on different factors and some of these factors can be controlled whilst others cannot be controlled as they are naturally occurring. As the farmer is to sell the crop to another party then the other party would also have different risks compared to the farmer, which is addressed in the research paper and an explanation is given to why the risks are for each party. "It is routinely assumed that landowners are risk-neutral and farmers are risk-averse." (Allen & Lueck, 1995, pg. 448), shows that landowners are the ones that are buying from the farmers and tend to be risk-neutral because "This dichotomy is crucial in generating predictions for real contract choices." (Allen & Lueck, 1995, pg. 448). The risk taken by each actor can be boiled down to what each actor is contributing to the contract, the farmers are more risk averse. They can predict their crop quantity more than the landowner hence, making the landowner more risk-neutral because all they are doing is investing in the farmers to carry out the tasks. The incomplete contract can be abused by the two different actors as "… actual contracts are incomplete so the assets can be damaged (farmers can abuse the land) by the effort choices of the other party." (Allen & Lueck, 1995, pg. 448). If such actions were done, then there would be consequences written into the contract, but such actions could result from the risky behaviour one of the party members is exhibiting. Risk preferences are crucial when considering the contract as it is a factor in the participants' behaviour. Since the researcher was deciding if risk-aversion was crucial in contracts, the researcher's conclusion states "… risk aversion is not useful in explaining contracts and, in fact, tends to distract economists from other important forces shaping contracts." (Allen & Lueck, 1995, pg. 450). The takeaway appears that the risk behaviour is useful to observe but specifically not risk-aversion as it will aid in creating the best contract possible. When a contract is to be made with individuals about their generated electricity, treat everyone as risk-neutral or risk-taking and that can lead to a contract that benefits each party. More the individual aiding to the electricity grid will help so, the likely solution for the risk-averse is to create a separate contract that would concentrate on them. To identify them, an option could be created that would entice them to choose that option. More about this could be found the Analysis section.

Once figuring out the risk preference for both the parties included in the contract, the core economic factor of efficiency arises. The efficiency question arises in the next research paper "Economic Efficiency Of Contract Law" (Daginawala, 2017) compares the previous theory of Bargain and compares it to the Contract Law or Contract theory. Bargain theory is where the parties would promise each other without any contract being drawn up to say they will fulfil their promise. The research paper goes in-depth about transaction costs and how they would be lost in translation under the bargain theory because there is no set amount the damaging party would have to pay. So, the victim party can pay as much as they want with zero repercussions. Hence the contract theory is more mainstream as "… by pre-defining the basic negotiations terms and making default terms, has enabled parties to be better off without incurring extra costs …" (Daginawala, 2017, pg. 5). There is structure in the contracts and can be referenced if anything major was to happen. Even in the conclusion, Daginawala reinforces this idea "The contract law by providing predefined terms for transaction between parties led to transaction costs. These predefined terms are used when enforceability is in question before the court …" (Daginawala, 2017, pg. 7). The use of contracts is well established in this paper and it would be logical to apply contract theory to the topic of this paper. As to create a contract with the individual and share their generated electricity to the grid for a plausible profit.

Next part of the methodology is the data section, in that section, the different data will be used to provide a visual representation of the individual electricity generation and how much the solar panels absorb compared to the level of sunlight available.

4.3 Data

This section is focuses on the solar duration for the different regions in Finland and the profitability calculation for a singular solar panel. The profitability calculation is borrowed from a company and the different factors that they used is explained. Then the data will be presented with an explanation of what is happening in certain graphs and specific units used.

4.3.1 What is this Data?

The thesis is concerned about the individuals supplying their solar panel-generated energy to the grid and information about the duration of sunlight would be beneficial. The dataset that needs to be pulled is the amount of sunlight that is available during the different months. Since the knowledge of the extreme dichotomy of day and night was established in the Background section of this thesis. That information can be called to understand why there is less sunlight in the winter compared to summertime. Since Finland has differing amounts of sunlight for where an individual is in the country so, the data must come from three different significant locations. As it is common knowledge that closer to the arctic circle, an individual is bound to extreme day-night changes whilst an individual further from the arctic circle is unlikely to experience such changes. Hence, there is bound to be different amounts of sunlight in the seasons. As there is a need to observe the entire country's sunlight amount so, the data had to contain three different sections of Finland: these sections being North, Central, and South. North Finland data comes from Rovaniemi lentoasema, Central Finland comes from Sotkamo Kuolaniemi and lastly South Finland comes from Jokioinen Ilmala.

The acquisition of this data was quite simple as there were many data sources to pick and choose from but all of them had this commonality of missing information for some time each year. This was observed after gathering the data from the different sources, the first issue stumbled upon is the lack of large datasets for some of the regions. Since this was an issue, rigorous research to find the optimal dataset source which will give a broad understanding of the sunlight availability. The data source used is from the Finnish Meteorological Institute (FMI) as there was more information than other sources which were outside of Finland and focused more on the popular places like Helsinki or Espoo. This was not beneficial for this study, since there was a heavy reliance on FMI there were bound to be gaps in the data. For example, FMI was not able to bring back data before 2010 hence the start date is from January 2010. The data pulled was very precise, in the sense that FMI was able to say how much sunlight was there for that specific day inside a particular hour. However, this is expected because the electricity bid market does run on an hour-to-hour basis and this specificity does help the paper to drawn precise averages. But within this data, there was missing information, and so the averages were affected. If the averages were to be observed closely there would be discrepancies but there is a minimal effect when taken into the larger picture.

The first set of data is the raw average sunlight availability for each month then it will be how much each solar panel can generate per that average. This leads to the next topic on how to calculate solar panel generation.

4.3.2 Solar Panel Calculation

For solar panel electricity generation, there are a lot of factors that affect this, such as the angle placement of the solar panel or the environment the solar panel is located. There are other factors as well which will be discussed further but the majority of this information is taken from a company in the United States of America that specializes in American Solar Panel placement. Vivint Solar is a company that assesses homes and places solar panels on individuals' homes. These types of companies are everywhere but the information provided about solar panel electricity is used to estimate how much electricity would theoretically generate.

Most of these factors can be broken down to the placement of the solar panel and some weather conditions. The placement of the solar panel is crucial to figure out because if there is debris in the way then that solar panel is not in the efficient spot it can be. The factors that were listed by the company are “Shading from nearby trees or other buildings, Excessive cloud coverage, Excessive dirt, dust, and pollution, Thick layers of snow” (*How to measure solar panels,*2022). Even though the latter third were weather-based reasons but that is an obstruction to solar panels achieving their peak efficiency. Since this company is based in the USA, the conditions in Finland are vastly different so, most of the conditions are applicable. Due to these prevalent issues, it is safe to assume that solar panels are either 50% or 75% efficient at capturing solar energy and turning that electricity. Once the solar panel efficiency is established, the other topic is the capacity of the solar panel. A typical residential solar panel has a capacity range of 250 watts to 400 watts and usually, there is more than one panel that is installed to maximize the total solar energy output. For simplicity, the assumption will be taken as one solar panel, but solar panels increase then greater the energy produced. Found to various news articles, the number of solar panels on an individual’s home ranges from 15 to 18 panels. This is all dependent on the size of the home and if the roof or the other place can hold the panels. With the assumption of one solar panel, the actual calculation for how many average watts in one year will be explained.

The way the monthly watts-minutes is by taking the average time the sunlight then multiplying that with the capacity of the solar watts and then multiplying with potential factors that are not affecting the efficiency of the solar panel. This formula was taken from Vivint Solar company with iterations to fit this paper’s purpose.

Average Sunlight x Solar Panel Watts x 50% or 75% = Monthly Watt-Minutes
Equation 1 (Source: https://www.vivintsolar.com/learning-center/how-calculate-solar-panel-output)

Working backwards, the efficiency is always taken to be either 50% or 75%. This is saying that only two out of four or one out of four factors are affecting solar panel efficiency. The factor that will commonly affect the efficiency is cloud coverage and the other factor that can play a role is the shade that falls on top of the solar panels. Due to the different factors, there will be two tables of data to show how the watts are affected due to the changing factors. The next variable to account for is the watts, as mentioned above the solar panel has the capacity of 250 watts to 400 watts, so there will be other sets of the table for these changes are well. Last on the list is the average sunlight available per month and this will be shown as a line graph.

4.3.3 Graphics

Due to the sheer volume of information that was collected and showing the graphs corresponding to it will not get the proper point across. So, the graphs and table mentioned in the prior section will be shown with an astute explanation of what is happening.

The first set of graphs shown are the Average Sunlight duration in the different parts of Finland starting from the year 2010 to 2019. The first graph is showing the data North of Finland and the place is very close to the article circle so, there are bound to be heavy swings in Sunlight duration. The second graph is the showcase of average sunlight duration in Central Finland. The last graph is the average sunlight duration in South Finland.

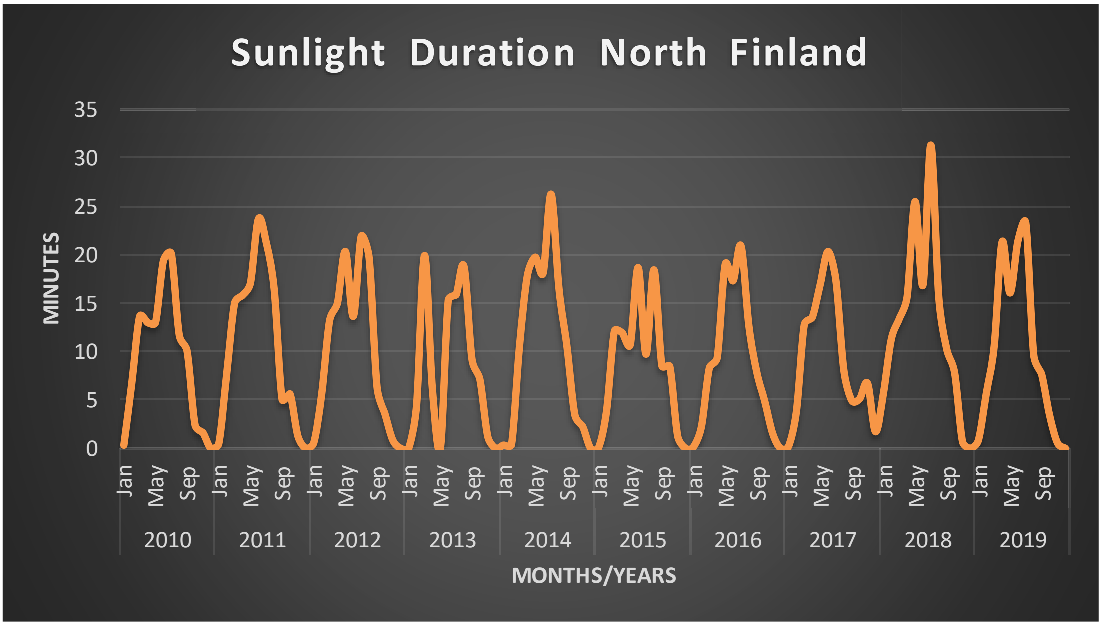


Figure 2: Average sunlight duration in Rovaniemi lentoasema (Source:FMI)

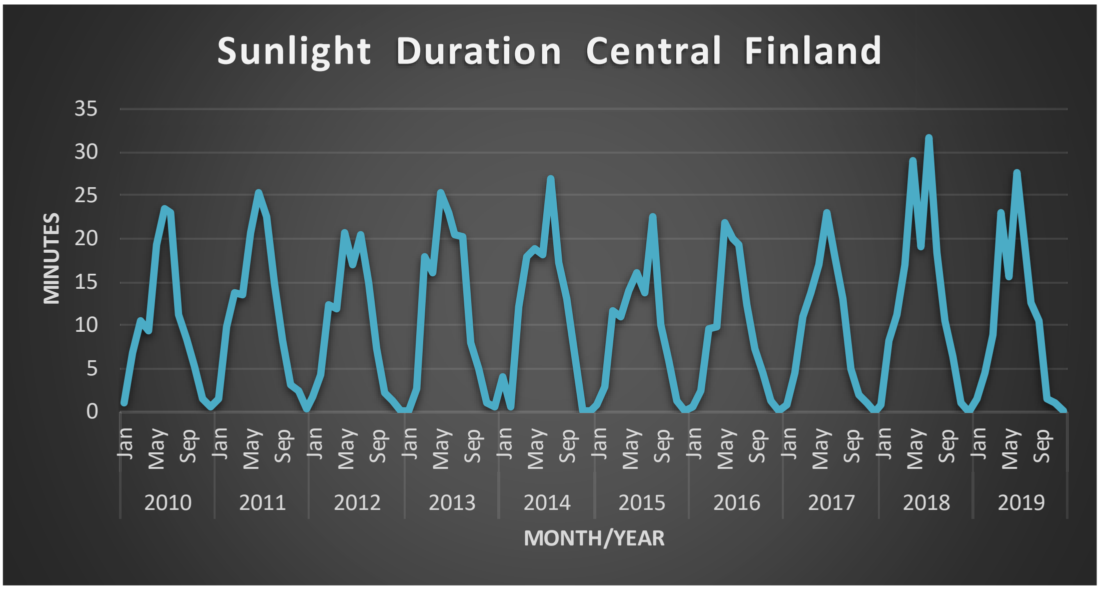


Figure 3: Average sunlight duration in Sotkamo Kuolaniemi (Source:FMI)

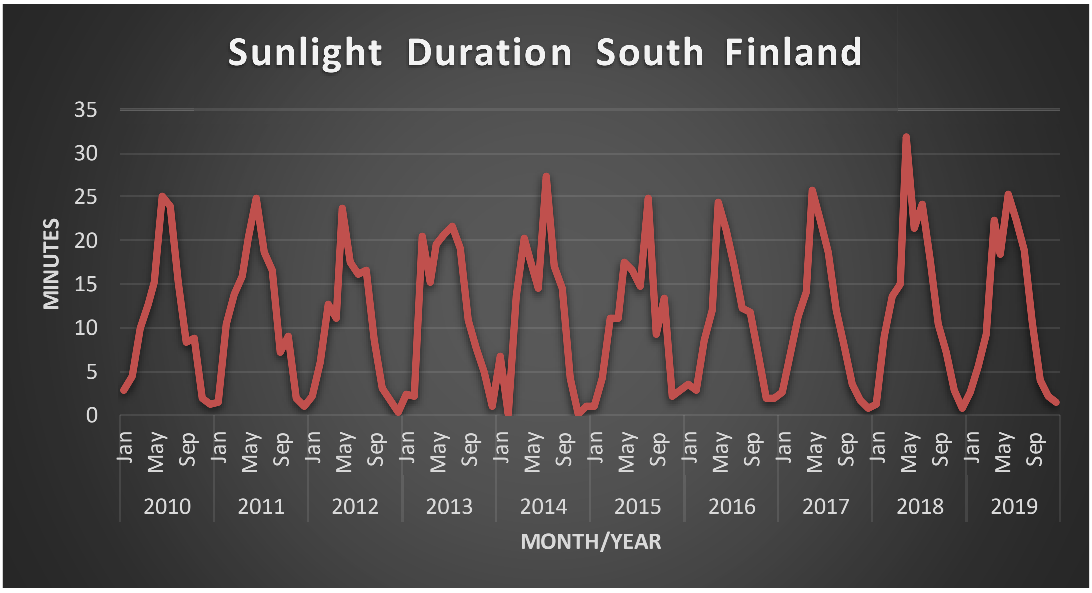


Figure 4: Average sunlight duration in Jokioinen Ilmala (Source:FMI)

Overall, the graphs present a cyclical motion of sunlight availability as each region goes through its summer and winter phases. One of many commonalities these graphs have is the great sunlight duration spike in the summertime of 2018. Through further research, there was a heatwave that caused the sun to be out more than the other years. Different news sources confirm that the summer of 2018 consisted of a heatwave with barely any rainfall or cloud coverage. Aside from that great spike, the average minutes of sunlight duration are around 25 minutes. This is the case for all the graphs shown here. The troughs are the times that wintertime has come and that means longer periods of darkness. However, in Figure 2 there is a big dip in May 2013 as that went to be one of the crests instead of being a trough. The explanation for did is due to the lack of data available on that month, hence there is such a crest in the middle of summertime. This comes down to a lack of data availability and should not be assumed that there was no sunlight during that month. This can be supported by observing the other locations and seeing how their May 2013 sunlight was accounted for. The other two graphs show a gradual increase in the crest of sunlight duration during that year so if this logic was to be taken back to Figure 2. Then, there would be a gradual increase in the crest to solidify this claim even further. Looking at the previous years within the same graph can lead to making an informed decision on the how the month's sunlight duration would be. Previous year's show the same gradual increase in the crest of sunlight duration as seen by other figures as well. So, this should validate the point that May 2013 would be gradually increased to meet the crest for that year.

When observing the highest year of sunlight duration to the lowest year of sunlight duration, there appear two years. The highest duration is 2018 for all the locations and the lowest duration is 2015. There is no argument for the highest duration because there are no other years that come close to the duration that 2018 exhibits. Whereas 2015 has some competitors for the lowest duration, mainly 2013, this was disregarded because the overall average of the duration is smaller. Even though there was a greater crest in 2015 compared to 2013, this crest is not the ultimate decider because of the entire year duration. This is important to point out because observing the extremes will give a better understanding of how much electricity would be created at the lowest point and the highest point of sunlight duration. The next table that is presented is applying Equation 1 and changes the factor from 50% to 75% but also changes the solar panel capacity from 250 to 400 watts.

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.91	170.71	113.81	2018	Jan	1.28	240.68	160.45
	Feb	4.29	803.57	535.71		Feb	9.03	1692.24	1128.16
	Mar	11.16	2093.02	1395.35		Mar	13.50	2531.50	1687.67
	Apr	11.17	2094.67	1396.44		Apr	15.05	2821.61	1881.08
	May	17.43	3268.65	2179.10		May	31.87	5975.92	3983.94
	Jun	16.58	3108.27	2072.18		Jun	21.35	4002.60	2668.40
	Jul	14.75	2765.81	1843.88		Jul	24.21	4538.81	3025.87
	Aug	24.80	4649.70	3099.80		Aug	17.63	3305.32	2203.55
	Sep	9.17	1718.75	1145.83		Sep	10.29	1929.99	1286.66
	Oct	13.27	2488.66	1659.11		Oct	7.21	1352.07	901.38
	Nov	2.20	412.76	275.17		Nov	2.86	535.34	356.89
	Dec	2.76	517.89	345.26		Dec	0.74	138.61	92.41

Table 1: 250-watt Solar Panel generation with 50% and 75% factors for Jokioinen Ilmala (Source:FMI)

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.91	273.14	182.09	2018	Jan	1.28	385.08	256.72
	Feb	4.29	1285.71	857.14		Feb	9.03	2707.59	1805.06
	Mar	11.16	3348.84	2232.56		Mar	13.50	4050.40	2700.27
	Apr	11.17	3351.46	2234.31		Apr	15.05	4514.58	3009.72
	May	17.43	5229.84	3486.56		May	31.87	9561.46	6374.31
	Jun	16.58	4973.23	3315.48		Jun	21.35	6404.17	4269.44
	Jul	14.75	4425.30	2950.20		Jul	24.21	7262.10	4841.40
	Aug	24.80	7439.52	4959.68		Aug	17.63	5288.51	3525.68
	Sep	9.17	2750.00	1833.33		Sep	10.29	3087.99	2058.66
	Oct	13.27	3981.85	2654.57		Oct	7.21	2163.31	1442.20
	Nov	2.20	660.42	440.28		Nov	2.86	856.55	571.03
	Dec	2.76	828.63	552.42		Dec	0.74	221.77	147.85

Table 2: 400-watt Solar Panel generation with 50% and 75% factors for Jokioinen Ilmala (Source:FMI)

Year	M	Dur.	75 %	50%	Year	M	Dur.	75 %	50 %
2015	Jan	0.79	147.43	98.29	2018	Jan	0.87	162.55	108.37
	Feb	2.87	538.50	359.00		Feb	8.28	1553.19	1035.46
	Mar	11.75	2203.88	1469.25		Mar	11.33	2124.50	1416.33
	Apr	10.89	2041.67	1361.11		Apr	17.09	3204.43	2136.28
	May	14.09	2642.39	1761.59		May	29.08	5452.37	3634.91
	Jun	16.08	3014.32	2009.55		Jun	19.20	3600.05	2400.03
	Jul	13.78	2583.17	1722.11		Jul	31.69	5942.54	3961.69
	Aug	22.55	4228.83	2819.22		Aug	18.30	3431.20	2287.47
	Sep	10.13	1898.44	1265.63		Sep	10.45	1959.64	1306.42
	Oct	6.02	1129.03	752.69		Oct	6.36	1193.30	795.53
	Nov	1.17	220.05	146.70		Nov	1.02	191.86	127.91
	Dec	0.08	15.12	10.08		Dec	0.00	0.00	0.00

Table 3: 250-watt Solar Panel generation with 50% and 75% factors for Sotkamo Kuolaniemi (Source:FMI)

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.79	235.89	157.26	2018	Jan	0.87	260.08	173.39
	Feb	2.87	861.61	574.40		Feb	8.28	2485.11	1656.74
	Mar	11.75	3526.21	2350.81		Mar	11.33	3399.19	2266.13
	Apr	10.89	3266.67	2177.78		Apr	17.09	5127.08	3418.06
	May	14.09	4227.82	2818.55		May	29.08	8723.79	5815.86
	Jun	16.08	4822.92	3215.28		Jun	19.20	5760.08	3840.06
	Jul	13.78	4133.06	2755.38		Jul	31.69	9508.06	6338.71
	Aug	22.55	6766.13	4510.75		Aug	18.30	5489.92	3659.95
	Sep	10.13	3037.50	2025.00		Sep	10.45	3135.42	2090.28
	Oct	6.02	1806.45	1204.30		Oct	6.36	1909.27	1272.85
	Nov	1.17	352.08	234.72		Nov	1.02	306.98	204.65
	Dec	0.08	24.19	16.13		Dec	0.00	0.00	0.00

Table 4: 400-watt Solar Panel generation with 50% and 75% factors for Sotkamo Kuolaniemi (Source:FMI)

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.07	12.60	8.40	2018	Jan	5.69	1066.03	710.69
	Feb	3.84	719.87	479.91		Feb	11.29	2116.35	1410.90
	Mar	12.11	2270.67	1513.78		Mar	13.38	2509.27	1672.84
	Apr	11.93	2236.98	1491.32		Apr	15.69	2942.71	1961.81
	May	10.71	2008.57	1339.05		May	25.50	4780.75	3187.16
	Jun	18.68	3502.60	2335.07		Jun	16.88	3164.06	2109.38
	Jul	9.73	1824.60	1216.40		Jul	31.34	5875.76	3917.17
	Aug	18.44	3457.66	2305.11		Aug	15.61	2926.06	1950.71
	Sep	8.54	1601.56	1067.71		Sep	10.26	1924.48	1282.99
	Oct	8.47	1587.70	1058.47		Oct	7.80	1461.69	974.46
	Nov	1.26	236.98	157.99		Nov	0.69	128.91	85.94
	Dec	0.00	0.00	0.00		Dec	0.00	0.00	0.00

Table 5: 250-watt Solar Panel generation with 50% and 75% factors for Rovaniemi lentoasema (Source:FMI)

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.07	20.16	13.44	2018	Jan	5.69	1705.65	1137.10
	Feb	3.84	1151.79	767.86		Feb	11.29	3386.16	2257.44
	Mar	12.11	3633.06	2422.04		Mar	13.38	4014.82	2676.55
	Apr	11.93	3579.17	2386.11		Apr	15.69	4708.33	3138.89
	May	10.71	3213.71	2142.47		May	25.50	7649.19	5099.46
	Jun	18.68	5604.17	3736.11		Jun	16.88	5062.50	3375.00
	Jul	9.73	2919.35	1946.24		Jul	31.34	9401.21	6267.47
	Aug	18.44	5532.26	3688.17		Aug	15.61	4681.70	3121.13
	Sep	8.54	2562.50	1708.33		Sep	10.26	3079.17	2052.78
	Oct	8.47	2540.32	1693.55		Oct	7.80	2338.71	1559.14
	Nov	1.26	379.17	252.78		Nov	0.69	206.25	137.50
	Dec	0.00	0.00	0.00		Dec	0.00	0.00	0.00

Table 6: 400-watt Solar Panel generation with 50% and 75% factors for Rovaniemi lentoasema (Source:FMI)

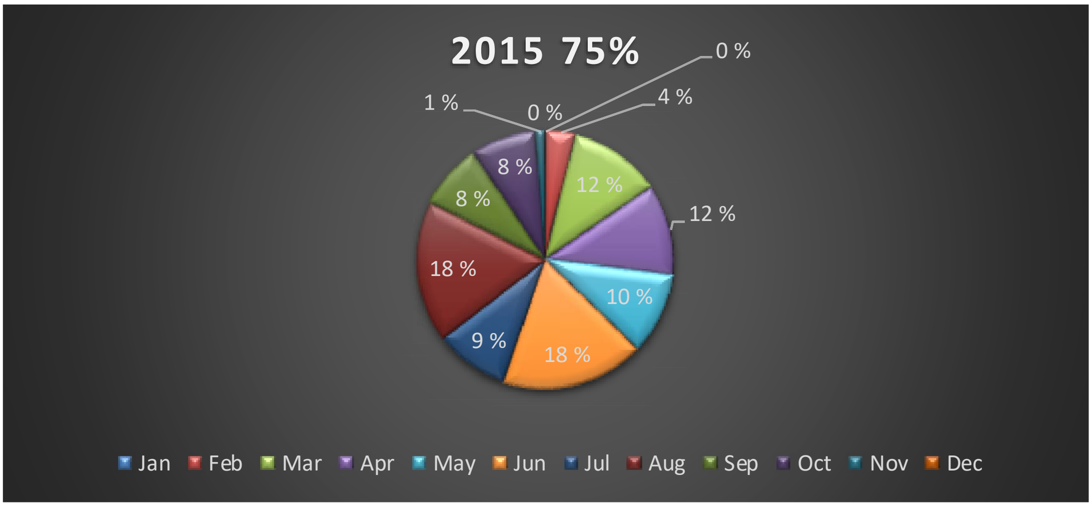
The tables show the proper amount of solar panel generation given certain conditions found within Equation 1. The tables are presented as such because the precise data is more informative with the different changes compared to other graphics. Later, a pie graph will be presented about how much each month in the given year contributes to the largest solar electricity production. This is to compare the two different years and draw an analytical statement. Aside from that, the focus of these tables is placed on solar electricity with different parameters. Most of the tables have the same explanation if the tables are looked at by themselves without comparing to its counterpart. The 75% factor rate always produces more no matter which year but the year 2018 always generates more electricity than 2015 be it with a 50% or 75% factor level. However, there is an exception to this with Rovaniemi lentosema and Sotkamo Kuolaniemi generating less electricity in the wintertime of 2018 to 2015. Since 2018 was taken as the highest average sunlight duration out of all the years and the same conditions held for 2015 but as the lowest average. In Table 5, during October for 2015 and 2018 the numbers stand for 75% factor is 1587.70 and 1461.69 respectively. The probable explanation for this is the different weather conditions that were present here and those that have not been accounted for. This is far too familiar with other locations as well. Most likely those factors are something that cannot be accurately factored so they would end up in an error term due to the sporadic nature of weather. This is consistent with other tables as well but if the topic shifts to summertime, then that is where 2018 distinguishes itself from 2015. Observations and conclusions done on the 400 watts for the different places apply to 250-watts as both fall the same pattern. Aside from the fact that 400-watt is producing a bit over 1.5 times the electricity. The month that has been selected is July which is often seen as the peak of Summer and that duration leads itself to show that duration is greatest then as well.

Starting with Table 2, the solar panel electricity generation for 75% factor rate in 2015 and 2018 is 4425.30 and 7262.10. There is a significant increase from 2015 to 2018. Since this was only the in Jokioinen Ilmala, the other places in Finland might yield different results due to the solar duration. The next observation is in Table 4, the factor is 75% with results coming from 2015 to 2018 and these numbers are 4133.06 to 9508.06 respectively. This is twice the solar panel electricity generation, and this data was taken from Sotkamo Kuolaniemi. Which is close to the arctic circle and the sunlight duration there tends to linger for a long time 2018 is still proving to be the highest average found in certain datasets. 2018 is setting the theoretical upper limit during the summertime as 2015 set the theoretical lower limit of solar panel generation. The last observation is shown in Table 6, with a 75% factor rate from 2015 to 2018 which is 2919.35 to 9401.21. The increase from 2015 to 2018 is roughly 3.2 which establishes that 2018 is the maximum for this dataset and sunlight duration in Rovaniemi lentoasema is far greater when compared to the rest of the country. As mentioned above, since the number was only picked from specific conditions the conclusion and observations can be applied to the different selections of the factors and the result will roughly be the same. However, when picking the different options do realize some conditions are not accounted for in the dataset. But overall results will indicate the same conclusions on how 2018 summertime solar duration is far superior when compared to other years in this dataset. This transitivity property is held to the different watt capacity for solar panels then it shows that a lot of watts are generated in with a singular solar panel in the reference point of minutes but if that was taken into hours. The calculation would entail taking the number from either 75% or 50% factor and dividing that by the 60 minutes to get the notation average monthly watts hours. For example, taking Table 5 with the year 2018, the month of July for the factor of 75% shows several watts minutes as 5875.76. Applying the calculation just said will yield a rough number of 97.93 average monthly watts hours. Since this is only using one solar and not multiple that is why the number of watt generation is low. The next table will showcase the change of values from Monthly Watts minutes to Monthly Watt hours.

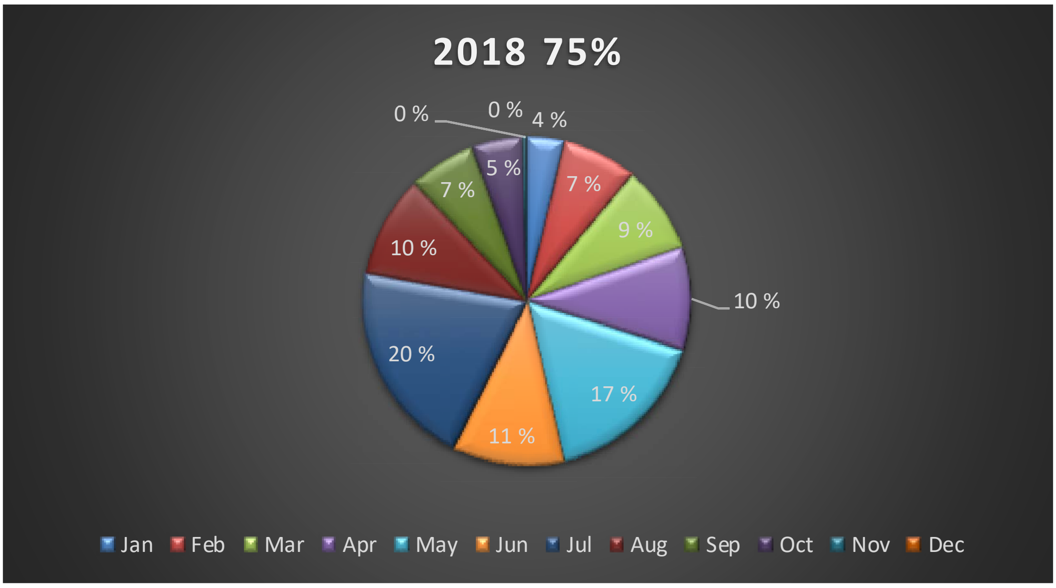
Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.91	2.85	1.90	2018	Jan	1.28	4.01	2.67
	Feb	4.29	13.39	8.93		Feb	9.03	28.20	18.80
	Mar	11.16	34.88	23.26		Mar	13.50	42.19	28.13
	Apr	11.17	34.91	23.27		Apr	15.05	47.03	31.35
	May	17.43	54.48	36.32		May	31.87	99.60	66.40
	Jun	16.58	51.80	34.54		Jun	21.35	66.71	44.47
	Jul	14.75	46.10	30.73		Jul	24.21	75.65	50.43
	Aug	24.80	77.49	51.66		Aug	17.63	55.09	36.73
	Sep	9.17	28.65	19.10		Sep	10.29	32.17	21.44
	Oct	13.27	41.48	27.65		Oct	7.21	22.53	15.02
	Nov	2.20	6.88	4.59		Nov	2.86	8.92	5.95
	Dec	2.76	8.63	5.75		Dec	0.74	2.31	1.54

Table 7: 200-watt Solar Panel generation with 50% and 75% factors for Jokioinen Illmala in Monthly Watt hours (Source:FMI)

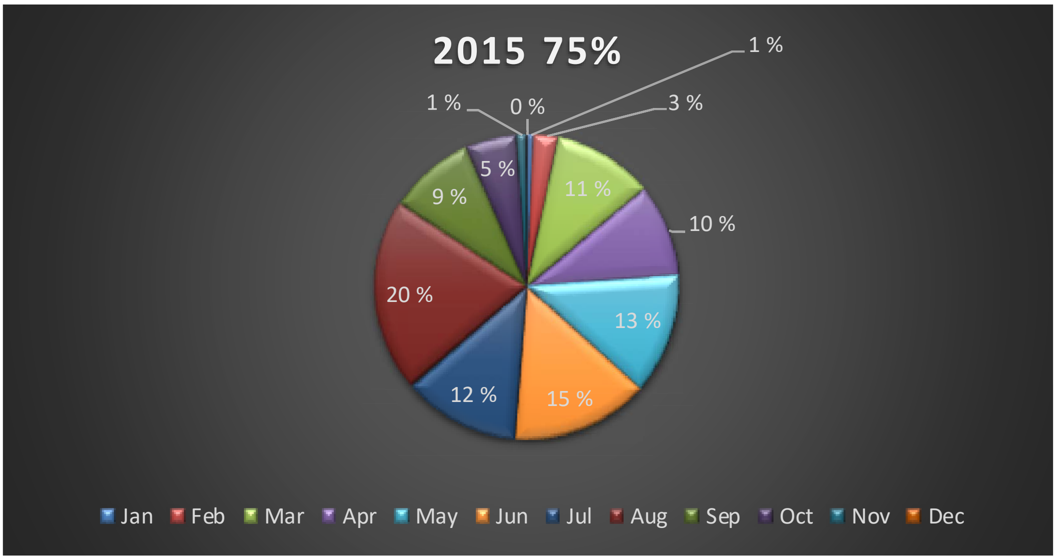
Table 7 represents the same information and the same conclusion, but the number value is changed to reflect the kWh term used in electricity as there are no kilo Watts per minute. For more tables like this, they can be found in the appendix section labelled from Tables 8-12. The next graphic is to show the percentage of solar panel generation in the two specific years of 2015 and 2018. It will be shown as a pie chart to better realize which month gives most of the solar panel electricity. The pie chart will only cover the 75% factor as the 50% factor would yield the same result and the capacity would not matter like this to observe the solar panel electricity generation.



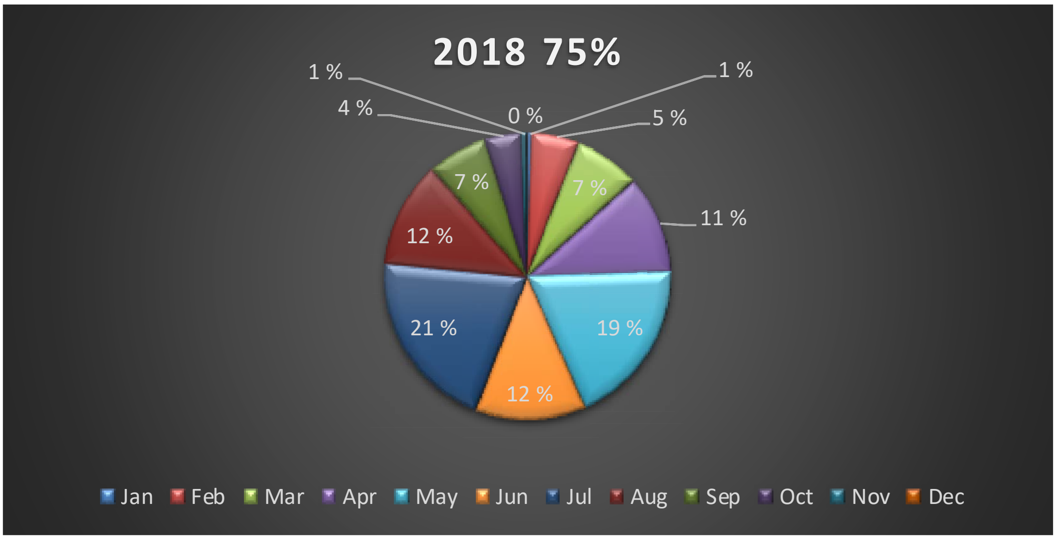
Graph 1: Solar panel Electricity generation 2015 in Rovaniemi Lentoasema (Source:FMI)



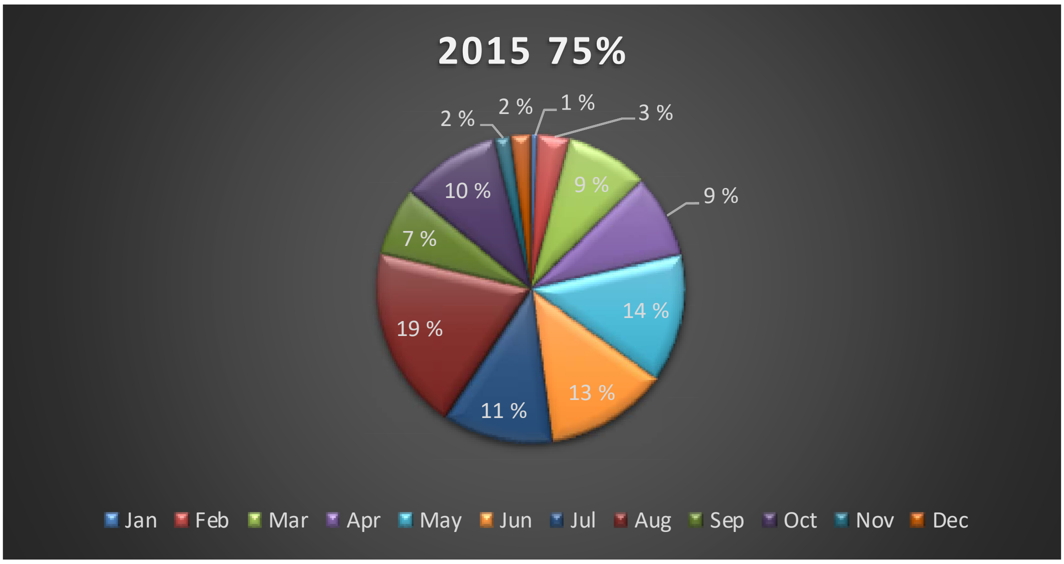
Graph 2: Solar panel Electricity generation 2018 in Rovaniemi Lentoasema (Source:FMI)



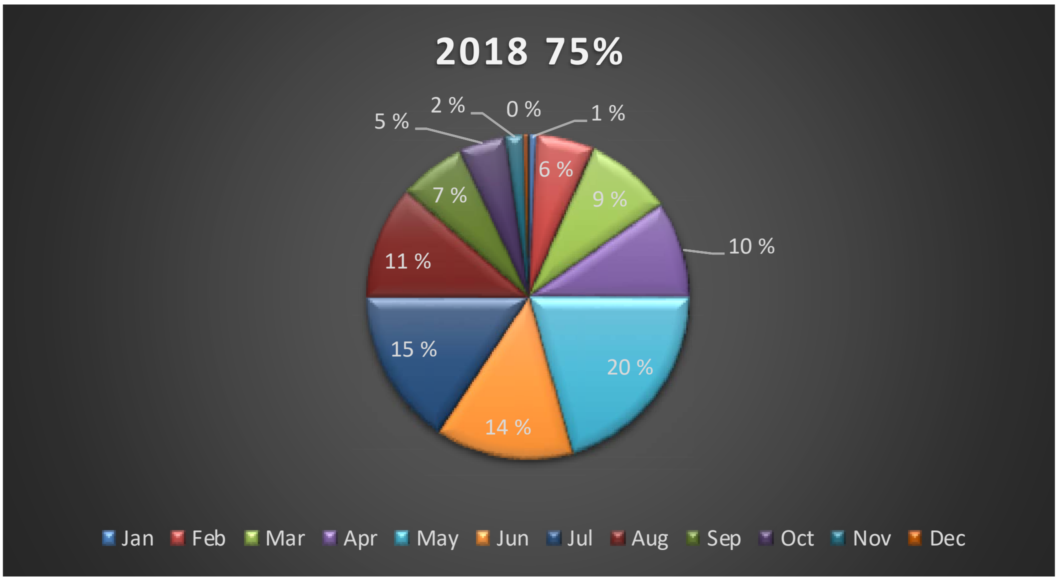
Graph 3: Solar panel Electricity generation 2015 in Sotkamo Kuolaniemi (Source:FMI)



Graph 4: Solar panel Electricity generation 2018 in Sotkamo Kuolaniemi (Source:FMI)



Graph 5: Solar panel Electricity generation 2015 in Jokioinen Ilmala (Source:FMI)



Graph 6: Solar panel Electricity generation 2018 in Jokioinen Ilmala (Source:FMI)

The analysis for these graphs is to show the higher solar panel electricity with some of the factors fixed. To start with Graph 1 and compare it with other graphs that hold the same factors fixed such as everything is fixed another only variable changes is the location. This is to compare locations and observe the data in 2015 which would lead to a statement about these graphs. The graphs are similar except Graph 3 is more diversified during the summer months compared to the summer months of other graphs. Solar panel generation in the summer months of Graph 1 and Graph 5 is similar together in the sense that the summer months' percentage difference is very close together. One other similarity found amongst those chosen graphs is that August held the highest solar panel generation except for Graph 1 as August was tied with June. However, the solar panels were able to produce a significant amount of electricity even on the lower end of the spectrum for the Sunlight duration availability. This same explanation does not hold for when the conditions change from 2015 to 2018. As there is a clear distinction between which month is producing the highest solar panel electricity. Of the three graphs that were not talked about, there is a clear difference in production percentages in the summer months. The percentages in the summertime are similar in the graphs except for Graph 2 as the solar panel generation is evenly spread through the month also, like the other Graphs there is no singular month that has generated significantly more than other months. For example, Graph 4 shows that July has produced more compared to the other months in that area. These Graphs carry two messages, those being that the month selected for peak solar panel production is true but also, that depending on the area where an individual is located, they are prone to experience varying effects of sunlight availability and solar panel electricity generation is dependent. These graphs paint a picture of where consistent solar panel generation would benefit and in which months.

This section was able to bring data and present different forms to show what the duration of sunlight was in the previous years and how solar panels were generated. This was achieved by observing the sunlight duration in the three different areas of Finland and highlighting the months that had the highest average sunlight duration and the lowest average. Once those two years were singled out as the extreme ends of each other, the calculation to figure how much Monthly Watts months with the changing conditions of the potential max watts for a typical solar panel and changing the factors that would affect the solar panels, be it 50% or 75%. Once these values were figured out, they appeared in a Table to show the vast range of how many watts were produced for that month given the different variables. From this table, the reason for choosing the optimal months was given a reason due to the solar panel generation. However, since the electricity market operates in Kilowatt-hour so, the monthly Watt minutes had to be changed to monthly Watt hours to better align with the market standard measurements. Once the solar panel generation number was found, the next graph included a pie chart of the two years and this time only the potential watts changed were observed here as changing the different factors would yield the same results with no difference. These graphs provided useful information as to which months provided the most solar panel electricity generation. The analytical breakdown has confirmed that July held the highest solar panel generation and more specifically in Rovaniemi lentoasema.

All the information gathered, and the theories learned will be applied in the next section as it is to bridge the theory and the data together to form a clear understanding of individual thinking about the financial prospects of the solar panel generation. The questions proposed in the introduction will be clearer and give way to an explanation for the answer. As there will be policies that are already in place and how could they upgrade due to the choices that some individuals are facing. These contracts, choices and the pathway to these choices will be explained further in the next section with the help of the data that was presented here.

5 ANALYSIS

This section is to bring what was talked about in the previous few sections and combine them to get a picture of how everything would work. The questions asked at the beginning of this paper will find their evidence in this section as every theory and data analyzed will be combined here. Which logical explanations on how the data supports the theory that was the explanation the in the previous section. Hence the explanation will be broken into the three subsections to dedicate time to explaining the contrivances in how each theory is used with the supporting evidence of data. Once the last theory to data connection has been made then the next subsection would be the policies. The explanation of the policies is under the contract theory, but the policies talked about here are the pre-existing ones and how they have contributed to the in help some individuals sell their generated electricity to the grid. During that section, there will be some suggestions to create new policies that will benefit the individuals. These suggestive policies will be taken from what was learned from the different sections and applied that knowledge to create a sufficient that will encourage individuals to the contribute their electricity. Once that is completed the next and final section will start which is the conclusion.

5.1 Theory-Data

To start the first section explained which is to express the different theories and how they are applicable with the use of data as an evidence tool to solidify the knowledge gained from the previous sections. Also, how the theories apply to the data that was presented will be a tool to draw conclusions and start to apply them.

5.1.1 Choice Theory – Data

The choice theory was introduced to understand how individuals will make a choice and from the previous section about this theory, the risk was introduced with supporting research papers on it would be applied in certain situations. Within risk, there were different types of risk and how an individual would into that, in that section everything said was theoretical but here there is data which can help to define these risk-taking and risk-averse individuals. The data which shows the duration will be more beneficial as the individuals will differently risk preferences can make an informed decision after observing the extremes of solar duration. The discussion will start will risk-taking individuals and how these individuals will respond to the solar durations. Then the same decision analysis will be applied to the risk-averse individuals.

Risk-taking individuals are bound to make a choice that involves a risky bet in a game. That logic can be applied here as well because the solar duration in any of the locations taken in Finland is similar whilst Rovaniemi Lentoasema hosts a higher duration compared to other locations. To break down risky choices a risk-taker would make is to look at the different solar duration for each location. Figure 1 shows Rovaniemi Lentosema solar duration and there is a good wave-like feature in the data. There is an even number of peaks and troughs, also during the peaks, there is strong solar duration. Hence the risk-taking individual would take and look at this graph, then conclude that there could be an investment in solar as the information is sporadic but there is a pattern that can be discerned. This type of thinking would be changed when they look at Figures 2 and 3. There are no big changes in the graph, even though there are peaks and troughs, but they are not at the level of Figure 1. This would be a safe investment as the data appears consistent, even on the extremes. Most risk-taking individuals will be pushed away from these sides of Finland and mainly invest in North Finland. Another incentive for these individuals to invest in solar panels cause how much electricity one solar panel can generate in one of the two capacities. Risk-taker would observe these numbers and probably conclude that solar panels generate a lot of electricity in Rovaniemi Lentosema. Hence, could lead to investing in solar panels and due to the abundance of solar electricity during the summertime, it is possible to make a profit by selling. To make such claims for the risk-taker is possible because Tables 1 and 2 show the exact electricity generation in monthly Watts minutes but if the individuals wanted to look at monthly Watts hours, then those would be found in Tables 7 and 8. Also, the individuals will know that summertime is best the choice for a solar generation because of either Figure 1 and 2 or Graphs 1 and 2. The first graph shows the duration of the sunlight whilst the latter is the composition of the sunlight in the extreme years of sunlight availability. The combination of these graphics will lead to a better choice and fulfills the risk-taker conditions of making choices. Risk-takers are more likely to respond to the situation, but the risk-averse individuals will have a different reaction.

Risk-Averse individuals were alleviated in the previous paragraph in which solar investment they would partake in would either be Jokioinen Ilmala or Sotkamo Kuolaniemi. These locations are a safer bet compared to Rovaniemi Lentosema because of the volatility that is since in Tables 1 and 2 but that same volatility is there but in a reduced effect in those other locations. Hence, these risk-averse individuals will gravitate towards it. There is consistency in those Tables and the thinking of a Risk-taker will reflect that this is a safe bet. This leads to an investment in these two areas, but more the Risk-averse individuals can only choose one as Jokioinen Ilmala is more consistent than Sotkamo Kuolaniemi. The consistency in data like this will help to assure the Risk-averse individuals that most summers will look like this. On top of that, these individuals will be reassured by the Table data that was presented and how close the number monthly Watt minute numbers are. Then the Graphs will show similar consistency of electricity generation in the extreme bipolar years. Hence, the individual will realize there can be again from the viewpoint of risk averse. For example, if the risk individual was to pick Jokioinen Ilmala then Tables 1 and 2 would be referred to. From those tables, the individual would see that the numbers are consistent within the two years. Table 1, the year 2015 summer months hold a consistent generation, and this is also for the year 2018 within the same table. The comfort of observing the similarity will weigh in for the risk-averse individual as mentioned. An easier comparison would be to observe Graphs 1 and 2, which will result in the same conclusion. The reaction of risk-averse and risk-taking is quite different, also the reasoning for why investing in solar panels is justified according to their risk personality. This applies to why they would hesitate or willingly sell their electricity to the market. However, the choices and the payoffs are best understood through the lens of Game theory as it offers a better understanding of this topic.

Choice theory gives a perspective on how a particular risk characteristic would most likely decide and why it is beneficial in their minds while considering the costs. The costs have defined this context as the purchase and installation of a Solar panel. However, as alluded before choice is broken into game trees to see what the process will look like.

5.1.2 Game Theory Application

This subsection is dedicated to making a framework of a game tree that would be beneficial to understand what the choices are if the different decisions were made at each tree. But first, the properties of the game tree must be explained before going further.

To start there is only one player and that player is named Individual who makes four different choices. The choices are not actual numbers but rather descriptive texts on what the reward is. The game tree went in this direction because of the changing spot price found in the grid and this game tree is very static thus, has some issues that cannot be explained here. Such as the solar panel cost is only prevalent in the short term but not in the long term and there is no way of representing this unless the game tree was extended to some years from now. Even if that is possible, that is leaning into unstable forecasting and even if that forecasting is reliable, even with many unseen factors. There is technology advancement that can better the solar panels of today to achieve better efficiency. Due to this, the rewards are arbitrary, and this game tree is to be seen as a decision that happens simultaneously. Since this is short term there is cost but the long-term cost would be decreased as the fixed cost will disappear. This only works if the individuals decide to continue selling to the electricity grid. From the cost to the benefit and the benefit here is classified as the monetary rewards and the personal benefit the individual is getting from the solar panel. The personal benefit is the supplication of their electricity, so there would be a small benefit if they decide not to sell. These are some of the rewards the individual would get if they chose one of the four decision nodes. Each decision the Individual can make is explained then the game tree is shown after that risk characteristic is applied to the individual which should match what was talked about previously.

Starting the initial node of the game tree, the Individual gets to make two choices and those are “Buy Solar Panels” or “Do not buy Solar Panels”. If the Individual chooses the latter decision, then the game would end, and they would end up with a payoff of (0,0). Which means they lost nothing and gained nothing. If the Individual chose the former option, then another set of options appears. They get to decide if they “Does sell to electricity grid” or “Does not sell to electricity grid”. The first option yields a payoff where it is (High Benefit, Cost), if they decide to take the second option then they receive (Low Benefit, Cost) payoff. Either way, the game ends here and they are left with these options with no further choices available. The diagram of the game tree can be seen below to see how it will play out visually.

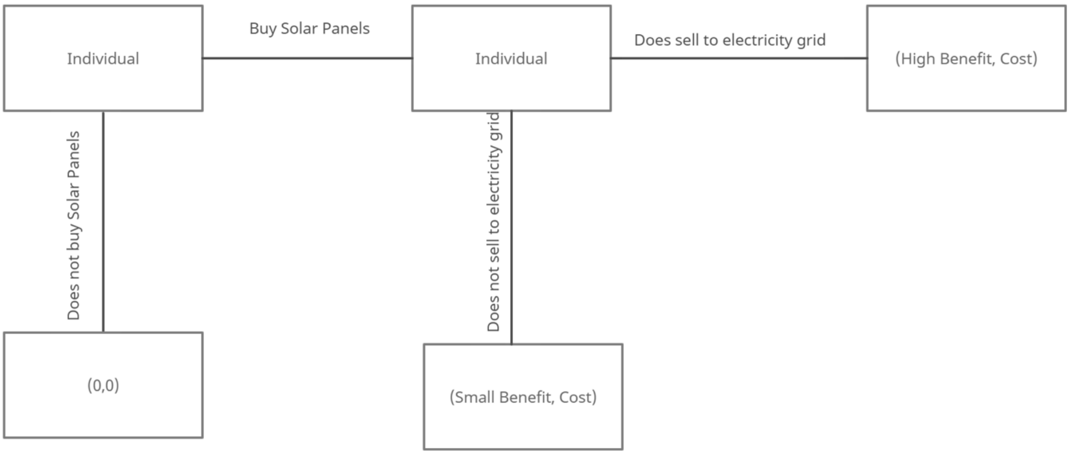


Diagram 1: Individual's Game Tree (Source: Self-Created)

The game is not complicated and is general enough to provide a piece of general information about the different risk characteristics that were talked about previously. Starting with the risk-taker individual, they are more likely to push forward in getting the solar panels for the first decision branch as solar duration is bountiful in the summer period. Also, the solar panel generation for one panel speaks volumes and the prospect would be enticing for the risk so they will buy the solar panel. Once the risk-taker comes to the next branch, the prices for the electricity are changing always. So, more information is needed here, or they can monitor the electricity prices themselves and sell when needed. But that involves too much effort for the individuals hence, that is not a probable solution. At this impasse, the risk-taker would choose to not sell to the electricity market and receive a payoff that includes (Small benefit, Cost). The risk-averse individual would not reach the second branch because it is safer not to get involved in buying the solar panel but if they did buy the solar panels then, they would end in the same decision payoff as the risk-taker due to the high uncertainty of the electricity prices. The difference between a risk-taker and a risk-averse individual is the risk-taker can continue to sell the electricity to the grid by receiving varying prices. Due to the lack of certifiable knowledge on how much the individual would receive if they sold their electricity to the grid, some contracts help facilitate this transaction between the grid and the supplier. This type of situation is real as there is no concrete information on whether these contracts will work and what contract is useful. As electricity is a dynamic system and navigating it can be a hassle hence, there are contracts that individuals will get into that will get a set price which the individual and the company supplying the contract can agree.

The next subsection advances into the intricacies of contracts that can be drawn up which can atone for the different risk characteristics of individuals. These contracts should help to change the individual's decision from "does not sell to electricity grid" to "does sell to electricity grid".

5.1.3 Contract Theory Application

Contract theory was understood in the previous section as an agreement between two firms but there are no two firms involved here. This theory will be derived to apply it to the parties that are present at the transaction of this contract. Firms will be taken as parties and these parties include the individual and the company, everyone is in their party. If the original definition classification of contract theory can be defined as two different parties reaching a contractual agreement and are bound by it for a certain period. These parties must abide by the terms and conditions, if one party does not follow these conditions then they must pay the remuneration to the victim party.

The purpose of the contract should incentivize the Individual to sell their solar energy to the electricity grid with a fixed price or take the spot price and apply that to what the individual is supplying. Dwell deeper into these two different contracts will reveal which risk characteristic would likely use. There are two parties to this contract, those being the Individual and the Company. Companies are the ones that will borrow the infrastructure to sell to the market and either give a fixed price or a variable price to the individual depending on the contract. This price must incentivize the individuals to not deviate from consuming their own generated electricity. Also, the price offered must be greater energy price the individual is paying. As mentioned in the Renewable section of this thesis, energy price and distribution price need be settled, and companies can offer a price fixed to better increase the involvement of the individuals.

However, this can be difficult for the companies as the spot price is always changing and no reliable way to provide a decent fixed price to incentivize the individual. So, the way to alleviate this issue is to make an offer where the benefits of selling their generate are far greater than consuming it. The price might be the deciding factor the extra information such as the social public benefit that can be received is far greater when contributing as the price of electricity for everyone will go down. The potential social benefit is a way to encourage individuals to contribute than consume can help change the individuals' minds be they risk-takers or risk averse.

Starting with the fixed-priced contract, this would cater to the risk-averse individuals as they know that price will be the same no matter what the price is in the market. The company that signed the contract will assure the individual will receive their fixed amount and if that is not possible then the company has to pay for breaking the terms. Risk-averse are more likely to lean toward this contract method because it is a safe bet, and they know that from observing the data presented that they can be profitable if they choose to stick with a sustained price. At first glance there is no, there little to no risk involved in the contract progress and the individual will most likely change their decision node from the "does not sell to the electricity grid" to the "does sell to the electricity grid". There is a little bit of caution because the individual and the company must come to agree on a price that both are happy with and if the individual is happy with the price, then they will change their decision. But if that is not the case then they will settle with the choice they made prior. Since the focus is to push the individual to sell their generated electricity then the fixed-price contract would be beneficial to the risk-averse individuals.

However, this fixed contract is only beneficial for the risk-averse individuals and the risk-taking individuals would not gain much from it. To work with these types of individuals then it is best to use a contract that will take the spot price. Due to the dynamic nature of the spot price in the market, there is uncertainty if the risk-taking individual will make a profit or not. This is beneficial for the risk-taker as they have always taken the risky bet and tend to follow that philosophy. The implementation of this contract can be daunting because there are a lot of moving parts and breaking them down would require another in-depth analysis of how it would be handled. This is not the focus of this paper, rather it is getting the individuals to give their generated electricity to the grid. Risk-taking individuals are always ready because of the prior parts it has been stated they will take on the solar panels more willingly. The data support this risky behaviour as shown by the volatile nature of the duration of sunlight. This type of volatility is an attraction centre for risk-taking individuals, and this supports their behaviour properly.

Through the use of contracts, there is financial gain for both individuals even though there is a cost involved in the payoffs. Which is often gone away in the long run, the profits gained from the fixed contract can sometimes be greater than the spot prices contract. This can be rare, but the profit is dependent on the rate that was established between the individual and the company. The spot price can be low if all the load is generated from renewables which is unlikely but possible, if this is the case then the spot price would be low. Even though the Tables are showing low, that number is further amplified when more than one solar is in effect. For example, to power, a decent-sized home would take about 18 solar panels but if those 18 panels were used in the calculation of the Tables, then that average generate would be higher. The high generation number would result in higher collaboration to the electricity which would result in a lower price for the other electricity users. Diagram 1 shows the Benefit gain which can be small or high, part of the benefit is instilled in social the individual will get and the personal benefit.

In Contract theory, it was stated that a contract cannot account for everything and there will be gaps in the contract in how to react. So, the volatility of the spot market is such an occurrence, and the terms cannot change because the spot price is greater than the fixed price. This is the risky option of taking the spot prices than the fixed price. Aside from this common example, there can be other instances as well, where the contract cannot say how to react to such a situation but of the time the contracts tend to be a full contract as best as they can with the reasonable forecasts. Since no one can accurately predict the future, there are always different factors that will affect the natural state. In the next section, there will be some real contracts that are currently being used to provide the services that are talked about. After that, some contracts should arise to introduce some of the risk-averse individuals to contribute their generated electricity to the grid. After that sub-section, this section will end then the conclusion will start.

5.2 Contracts

The contracts mentioned above are available but in a border sense with some customer rewards associated with them. The purpose of this section is to look at the different contracts that are available and offer new contracts that can be more efficient in the how they deal with the different risk characteristics. Most of the contracts are taken from the websites of the energy company in Finland their website links are provided in the Reference section. The two main companies for Finland will include LumoEnergia and Helen. Each company has different contracts that help the Individual to provide their solar electricity generation to the grid per the agreement made with the company.

5.2.1 Current Contracts

These two companies are providing the same service with similar pricing models. This pricing model referring the hourly rate on the electricity grid. To go into more depth with these two companies to see what exactly the contract contains and apply the different risk characteristic of individuals to the situation to gauge their potential reaction to the agreement.

Starting with LumoEnergia, the preliminary condition for the individual is to have their solar panels connected to the electricity grid and have a "bidirectional meter". This meter in layman's terms is the measurement of the individual's consumption and export of electricity to the grid. Essentially it is a measurement tool that helps to measure how energy is being sent to the grid versus how much an individual consumes the energy from the grid. The price that LumoEnergia is offering is reflective of how much the grid is offering for the specific hour. However, there is a service that LumoEnergia takes as they are providing direction from the individual electricity generation to the grid. Hence, the company takes a small fee from the hourly price the individual gets from supplying to the electricity grid. A small clarification is made here as the electricity grid in Europe is quite extensive compared to other parts, the rate is decided and taken only from Finland. Since the infrastructure is in Finland and so the monetary gain would reflect that. The reactions of the different risk characteristic risk individuals change but this type of scenario was alluded to before.

The risk-taker would gladly take this contract as the operating in a changing dynamic is no stranger to them while the risk-averse would not engage in this contract. There is no safe investment that is seen for the risk-averse individual and so, this individual would regress in their decision not to sell to the grid or even regress further in their decision tree to not to buy solar panels. However, the risk-taking individual would take this contract and cherish it as there are significantly beneficial to taking the price from the electricity grid. If this individual was purely concerned about profit from the solar panel generation, then the service fee would be too much of an ask and they can try to work that down or go to another company that will give a better deal. The next company draws a similar contract as this but without the service fee.

The company Helen can offer the price of the electricity market for what the individual can produce. There is no service fee and the individual signs a contract with this company and then takes the market price for the generation that is supplied. This contract is very similar to the one seen before the only difference is the service fee. The risk-taker individual would take this contract compared to the other one if they were purely concerned about profit because there is no service fee for the generation of the electricity. However, the risk-averse individuals will still not partake in this contract due to the high volatility of electricity prices. But there is a chance for the risk-averse individuals to participate as this company allows the individuals to rent solar panels and the profits the individual makes go directly to them without any of the service fees other than the monthly fee of renting the solar panel. There is a great benefit to this as the risk-averse individual need not make a high sunk cost but rather pay a variable cost each month and if the electricity market prices are sufficient then the individual will take the profits and pay forward the next month. Then take the remaining and it to their finances. However, the risk-averse individual still faces volatile electricity market prices and that can still lead them away from solar panel investment.

To engage risk-averse individuals, new contract terms need to be established with defined parameters. If these individuals can interact with the market more but supply, then the social benefit will increase for everyone. One of the components that were missing from these contracts were certain terms and conditions, the service fee is there but it could be seen as a deterrent if the risk-taking individual sees no major benefits from supplying to the market. Instead, they would find a benefit in consuming their own generated electricity, which again would be bad for the social benefit. In the next section, this paper will provide suggestions that can help to make a potential contract that can cater to different risk characteristics of individuals. While catering to the individuals, it should also help the other party as well.

5.2.2 Suggestive Contracts

The contracts that were listed above helped to define the financial structuring of how these contracts would go but the issue with these contracts seem to cater only to the risk-taking individuals. The risk-averse individuals would not step in to take this type of contract due to the volatile prices present in the electricity market. Hence, a contract must be made where it includes all the risk characteristics. The benefit of getting all the risk characteristics will mean that there is more solar energy, especially during the summertime to use instead of relying on more expensive choices. As all the risk characteristics join to contribute to supplying the grid would mean there is a higher social benefit for everyone. This is achieved through the lower price that can be gained from using renewable more than the other carbon sources. To achieve such a result, a contract must be formed. Incorporating what the other companies did for the pricing model, that shall be used expect there would be an option to for a fixed price. This fixed-price notion comes from the idea which was introduced back in the previous sections. The risk-averse individuals are keener to participate when they know the price will stay the same no matter how the spot price is behaving.

To determine this price will be interesting because the company is ultimately making this price and this price will act as a threshold regarding the spot price. As long the spot price is greater than the fixed price then the company would benefit as they can the surplus revenue from the fixed price the individual agreed. However, if the spot price does not break the threshold of the fixed price, then the company must pay the difference to the individual to uphold the agreement. As that would be written in the terms and conditions which both parties must have signed for the agreement to proceed. This deal with the risk-averse is plausible and can work to have the risk-averse individual contribute to the electricity market, with this contribution there will be more renewable sources in the pool to push the price of electricity down.

There is however a flaw in this contract because there if the risk-averse see that taking the spot prices is more of a beneficial deal than taking fixed then those individuals would switch their plan to take the spot price. To stop such a move the company can decide to increase their service fee and that could deter them, but such a move would push the risk-taker individuals as there are better contracts other companies are offering compared to this company. To fix the individuals from switching their plans from fixed price to spot price, there can be a fixed term on the contract that prohibits the individual from changing their plans. The other contracts do not dwell on this information but look at the electricity contract that one can sign for their electricity. That contract is usually monthly, that same concept can be applied here but without the monthly part. Take the contract to be of a fixed price for one year, within this year the individual must agree they will not switch from their pricing. This will ensure the individual will stay with that singular price for a year.

This contract has focused on the risk-averse individuals, but what about the risk-taking individuals. They too can participate in this contract for the fixed price if they wish but they intend to take the spot price and benefit from there. One of the companies had a service whilst the other did not. It was mentioned that if the risk-taking individual is solely interested in maximizing their profit, then they would not go with the company that had the service fee. However, for this company, the contract must include a service fee as there is no secondary mode of gaining profit. The company that was offering no service fee, they were allowing the rent of solar panels and were able to make a profit from that. Due to that extra business, they can manage however the company that is making this contract is only engaged in the fixed price and the service fee would help.

The basis of the contract is made, and the overview shall be reviewed to help the risk-averse individuals enter the electricity market so they can supply their solar panel electricity generation. The contract is stated as such, the individual is to supply their generation to the electricity grid and will receive a fixed price on the quantity that was given. This price is to be decided between the individual and the offering company. This deal is sustained for one year of the signature signed date and the individual cannot change the price until one year is completed. Then this contract will be up for review to either continue the same agreements or change to a new agreement.

In the mock contract, there is no reference for service fees because the contract is targeting the risk-averse individual and to increase their activity in the electricity grid. The contract is not to be taken literally but as an example of how negotiations would look in the end. The hopes of this contract will bring in risk-averse individuals and change their decision node from “does not sell to the electricity grid” to “does sell to the electricity grid” in Diagram 1.

This Analysis section has taken all the learnings from different sections and used that knowledge to understand how the questions proposed in the Introduction can be answered. This section is a supporting section to the questions that will be answered in the Conclusion. Drawing conclusions required the help of theories and the data to establish a common ground. Where the main topic can be discussed without any confusion and prepare a diagram that will help to understand the thinking of the individuals. Also, how each characteristic would act if given those exact choices. From there came how different companies will provide their contracts and was established those risk-taking individuals would take these opportunities but not the risk-averse individuals. To facilitate risk-averse individuals to contribute, a new contract was made that suited the style of risk-averse and would encourage them to act. With the creation of this contract, the company and the individual were considered. In the contract, a clear specification was discussed and how to hold the individuals from switching the pricing model immediately by adding restrictions. A complete contract was not written as that is a process and this paper is to help build a format for such a contract to exist.

The last section is the conclusion which brings everything learned from these other sections into one and summarizes them. Also, answers the questions that were posed in the Introduction.

6 CONCLUSION

Main topic of this thesis was to get different risk characteristic to invest into solar panels for their household then supply that generation to the electricity grid. Many research papers have discussed the untapped potential of solar panels in Finland due to the high solar duration that Finland contains. These research topics have aided this thesis to create a foundation to suggest different plans to implement the solar panel usage. Through different theories called upon and a dataset solidify potential contract this thesis has purposed. This potential contract contributes to the mini questions that were asked in the Introduction section.

The questions stemmed from each other and helped understand the progression of how solar panels can be useful. First question is how to make solar energy more prominent in the grid? Then what is the individuals' cost/benefit analysis and is supplying the electricity is financially rewarding? Also is there any potential social benefit? These four questions were answered with plentiful background information to support the answer for each.

Since this thesis is focused on solar energy and making it more viable in Finland. The renewable energy sources have mainly been diluted by either Hydropower or Wind power. Solar energy is possible to work in Finland and this thesis was able to prove this point as the first topic starts with the key research papers that have covered the solar radiation availability in Finland. The papers used in the Literature Review are crucial because they have explained how to increase the solar usage, and this could be done through personal homes. Through this knowledge, the question on how to make solar energy more prominent in the grid is increase the supply of solar panels and this is done through individual participation. Through participation of individuals this is possible but what are the cost benefit analysis for them, what are they getting at the end if they choose to contribute. These questions are answered in the next paragraph, but some knowledge needed to understand to better understand these costs and benefits.

The Background section is presented to gather all the general knowledge into one section so, that everything can be explained to get a clearer picture on the different energy sources and how the electricity market worked. Also, some of the sections rely on this background information as support and generally assumes that knowledge gained from this section is applicable everywhere else in this paper. The background section starts at the beginning with what was used as an energy source and how it was generated. Then how different energy sources started to emerge and the specification that each energy type would fall under. Due to the subject area this thesis paper deals with so, more detail was given to solar energy and how solar panels are used in the market if an individual decides to give to the electricity market. The market structure of electricity would operate was discussed heavily with emphasis on key points as they would prove to be crucial in the future sections. Within this discussion, there are different vocabulary that were learned to assist with future sections as this vocabulary and knowledge would be called upon. The main learning point from the electricity market is that generation from renewables will result in a lower spot price. There is a dichotomy of solar duration as it correlated to which season Finland is currently running. The summertime duration is by far the longest however, this is the opposite for the winter period and this explainable by the positioning of the country and the different regions that is to be observed. This would conclude this section has it was to introduce the concept and set a foundation for the next few topics.

Methodology section was used to aid the Analysis section which in turn helps to answer rest of the questions asked. Methodology section is broken into theory and data section. Each provides helpful knowledge on how to answer these questions but also insight into individual decision-making. The main theories that were introduced hada commonality with choice theory and so, choice theory gave meaning to how individuals were making their choice through the different risk characteristics. Two risk characteristics were selected because they represented the extremes, and they are risk-takers and risk-averse individuals. These risk characteristics make up core of this thesis so, this section was able to fully extrapolate the information of these characteristics. Previous research papers have been provided to explain these characteristics, but these research papers were not randomly chosen as they were chosen given the context of this thesis paper. A particular research paper was referenced to give evidence for these risk characteristics and why there is behaviour justified. This research paper was able to provide ample evidence about the behaviours hence, this theory is prudent to this thesis paper as it explains these characteristics splendidly.

Game theory is used for one singular purpose here and that is game trees. Game trees bring forth a visual representation of the different choices that were available in the different time periods and the payoffs. Two research papers were introduced to explain how the Game theory was useful in the context of energy economics and the implementation have inspired the actions this thesis paper would take. These papers focused have shown the effective use of game trees in a real-world situation and from their conclusion, the game tree was useful to observe the choices each party. Due the proved effectiveness of the game tree and the observational skills, that is why game tree are present and is made with the assistance from these papers. Game trees only assist to the bigger theory this thesis decided to focus on.

Contract theory main function was to provide a link with the individuals to give their solar-generated electricity to the grid and ensure a way to get them to sign the contract. Economic analysis of Contract theory is based on the efficiency of the contract and how to make sure it can be benefitable for parties, in enseence reach a pareto optimal. Since the topic about different risk individuals and their decision making one research paper was introduced to show how different risk characteristics individual would interact with the contract. This paper was able to connect the different theories that were explained before and the connection would prove useful to better justify the actions of the different risk characteristics. Contract theory section was able to provide information by taking the previously discussed theories and applying them. This connection was enough to prove that these theories can be connected and have been connected to previous research papers. From the theories came the data, the focus was on solar duration.

Data section focused on the origins of the data and the complexities of the dataset. The data was taken from FMI and some of the solar duration for the places that were selected were not present at the time. Hence, some leniency was taken when observing the data. The data were selected from three different spots in Finland as the solar duration is different in the summer months depending on the location. The three locations encompassed the North, Central, and the South of Finland to get a better indication of the solar duration. Once the origin of the data was confirmed, the next part was the equation that would transform the data. This equation is a calculation of what the average monthly Watts minutes would look like after applying the average solar duration. Equation 1 is referenced here and the main observation to be made here is the number is under minutes designations and from the background section knowledge, electricity is counted in hours; this table can be found in the appendix section. The graphics included a line graph, a table of information, and a pie graph. The graphics shown the different data in a graphic form to present the data that was easily understandable. The question of what the cost/benefit analysis are is answered with the help of these graphs. The cost individual incurs is the cost of installation of the solar panels. The benefit is when they supply to the electricity grid, they can get paid for energy they are able to send. This in turn relates to the question of Financially viability, which is to say it is financially viable because as long they can send the electricity to grid. Indeed, the question of profit for the individual is dependent if the energy price is lower than the price the company is giving to the individual and if that is the case then individual turn a profit. This financial reward is a key component for the individuals as it can incentive for them to invest into the solar panels and provide them to the grid with the help Contracts. Contracts helped to provide a framework for the individuals to supply they solar generation and this generation would help to lower the spot price as learned from the first section. The electricity market supply curve will shift to the left which leads to show a lower spot price for the individuals that using the electricity. This would be seen as a social benefit and gives answer to the final question that was purposed among the questions in the beginning.

Everything is connected in the analysis section with different graphics used in the previous section to make an appearance here but changed with increased solar generation sources and supporting evidence. All the questions were answered above the analysis section brings all the components of this paper to apply them together. As all the theories and data were represented on their own accord, through the analysis section everything mentioned is brought together. In this section each theory gets associated to the data and how the data proves point understand the context of this thesis topic.

Choice theory and the data is the analysis of the different risk characteristics would react to the data that is present in front of them. In that section, the probable reaction was assumed due to the results presented by the data and the different graphs showcased the scenarios for the different locations that were taken. Different risk characteristics had reactions according to the locations because the data graphs have shown different intensities of solar duration. Depending on the risk characteristic, the individual would choose either to invest in changing or stable solar duration. In addition to the solar duration observation came the raw data which would show the solar panel electricity production for one panel and how it would change in the different months depending on the location as well. The choice theory was able to give an insight into how the individual would formulate their choices. The next application is taking these choices and laying them in graph form to show what choices everyone has and the payoff they would receive.

The second application is applying is creating a game tree and applying the choices the individuals have access to. From the choices, the next set was the payoffs, which was broken down into benefit and costs. These were selected as the individual would be getting the monetary value and the social value, since it is rather difficult to showcase these values, they have been reduced to benefits. While the cost is explained as the solar panel acquisition and discussed that if the individual was to supply to the electricity grid, then that cost would disappear in the long term. This topic would go on further to show the path the risk-taking individual would take compared to the risk-averse individuals. It was concluded that risk-taking individuals will take sell at the market, but the risk-averse individuals did not wish to risk play that risk and their decisions would regress to not getting the solar panels. Which was not beneficial so, a proper contract had to be made that would incentive the risk-averse individuals. The next theory comes into play as shows how a contract should act and the intricacies within it.

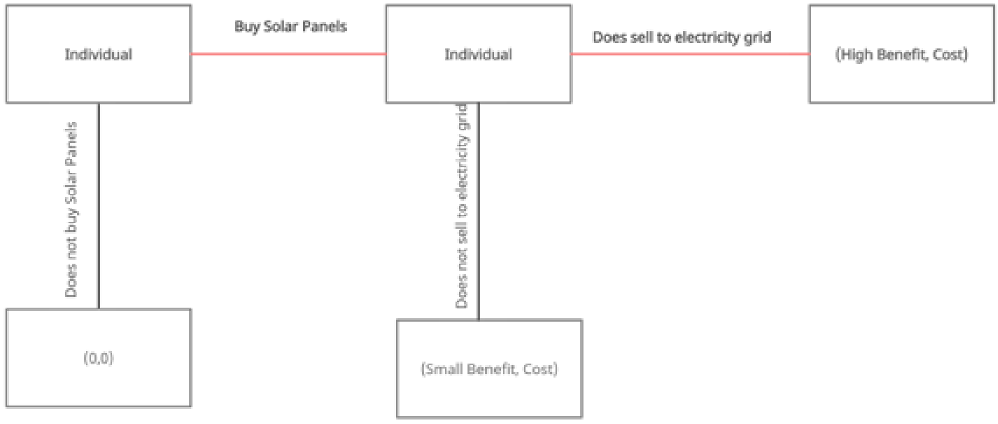


Diagram 2: Preferred Choices for Individuals (Source: Self-created)

As mentioned in the previous paragraph, the preferred pathing choice for individuals to make is shown in the diagram above with the red lines indicating the direction. This would lead to social benefit that as discussed thoroughly in the previous sections. Those were through contracts and that next summary to be explained.

The last section is the contract theory application, real-world contract was brought forward to observe the situation. From the two companies, these contracts catered to the risk-taking individuals and no contract existed for the risk-averse individual. So, to devise a new contract or a format it would take was to take the pre-existing contracts and interject the clauses that will help the risk-averse individuals enter the market and supply their generated electricity. The social benefit was hinted at extremely due to the benefits that would arise from more solar renewables contributing to the market load. This contract was devised where the company providing would be financially compensated for taking this company with the individual. The contract details include the individual and the company will agree to a fixed price and the individual will supply their generation to the market. If the spot price is higher than the fixed price, then the company would receive the surplus revenue but if the spot price is less than the fixed price then the company would have to pay the difference to the individual. Also, this contract would have a fixed term of one year before it needs to be reviewed. The complication of a real contract would include specific details, but this is more of a framework on how everything should work. As mentioned earlier the inclusion of risk-averse individuals in the market would result in a greater social benefit as the spot should decrease from the previous years.

The topics discussed entails how different risk characteristics individuals can contribute to the electricity market by supplying their solar generation. Solar energy is viable in Finland due to the duration of sunlight that is available in the summer months and in some places in Finland, the solar duration is reduced to only a small effect in the other months. Individuals have the chance to partake in this solar energy by acquiring solar panels and installing them. However, due to the dichotomy of weathers found in Finland, their gains can enter a metaphorical dry period in the winter months but that is a small price to pay for the intensity of the solar duration in the summer. All this is backed by the data that was presented, as the generation of one solar panel shows a significantly small number by multiplying ten different solar panels then the marginal benefit will exceed the marginal cost. Since solar panels achieve peak efficiency during summer, the financial gain of selling the electricity is only heightened as revenue will report a strong financial report for using these solar panels. Some contracts can help every individual and this paper has introduced a new contract for the individuals that are a bit more risk averse. So, this venture will be financially rewarding and socially beneficial. There is a social benefit because with the increase of solar energy sources contributing to the electricity load, the spot price will be reduced for everyone, and the use of carbon generation sources will significantly go down as well.

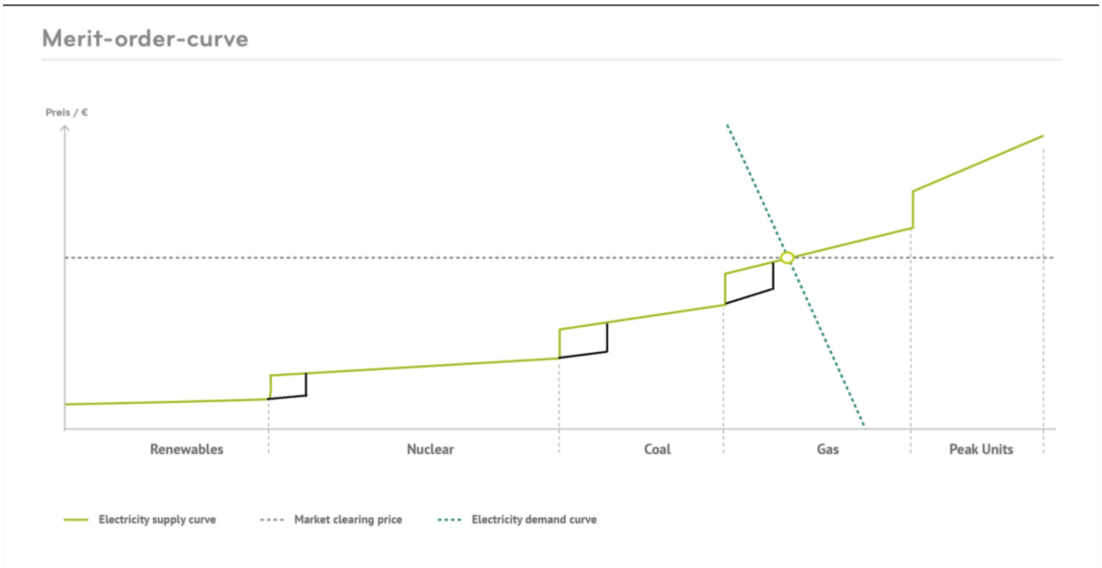


Figure 5: Adjusted Electricity market graph with potential solar sources (https://www.next-kraftwerke.be/en/knowledge-hub/merit-order-curve/)

The questions asked in the introduction have been answered with the support of the data and theories that were introduced in this paper. The goal was to understand why the individual was not investing in solar panels and if they did then, why were they consuming their generated electricity. This was successfully answered throughout the paper but a focused answer using the knowledge gained throughout the entire paper was created. There is still more research that can occur on this topic as the contract that was made only scratched the surface and different terms and conditions can be developed more. Also, the factors affecting the individual choice for choosing either to invest in a or not invest can be researched more to further the cause of the understanding of the logic behind the individual's decisions. All in all, this paper shows how different risk characteristics would choose not to enter the electricity market and in turn, this paper offers solutions that can help to enter the market with ease.

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8 APPENDIX

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.91	4.55	3.03	2018	Jan	1.28	6.42	4.28
	Feb	4.29	21.43	14.29		Feb	9.03	45.13	30.08
	Mar	11.16	55.81	37.21		Mar	13.50	67.51	45.00
	Apr	11.17	55.86	37.24		Apr	15.05	75.24	50.16
	May	17.43	87.16	58.11		May	31.87	159.36	106.24
	Jun	16.58	82.89	55.26		Jun	21.35	106.74	71.16
	Jul	14.75	73.76	49.17		Jul	24.21	121.03	80.69
	Aug	24.80	123.99	82.66		Aug	17.63	88.14	58.76
	Sep	9.17	45.83	30.56		Sep	10.29	51.47	34.31
	Oct	13.27	66.36	44.24		Oct	7.21	36.06	24.04
	Nov	2.20	11.01	7.34		Nov	2.86	14.28	9.52
	Dec	2.76	13.81	9.21		Dec	0.74	3.70	2.46

Table 8: 400-watt Solar Panel generation with 50% and 75% factors for Jokioinen Illmala in Monthly Watt hours

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.79	3.93	2.62	2018	Jan	0.87	4.33	2.89
	Feb	2.87	14.36	9.57		Feb	8.28	41.42	27.61
	Mar	11.75	58.77	39.18		Mar	11.33	56.65	37.77
	Apr	10.89	54.44	36.30		Apr	17.09	85.45	56.97
	May	14.09	70.46	46.98		May	29.08	145.40	96.93
	Jun	16.08	80.38	53.59		Jun	19.20	96.00	64.00
	Jul	13.78	68.88	45.92		Jul	31.69	158.47	105.65
	Aug	22.55	112.77	75.18		Aug	18.30	91.50	61.00
	Sep	10.13	50.63	33.75		Sep	10.45	52.26	34.84
	Oct	6.02	30.11	20.07		Oct	6.36	31.82	21.21
	Nov	1.17	5.87	3.91		Nov	1.02	5.12	3.41
	Dec	0.08	0.40	0.27		Dec	0.00	0.00	0.00

Table 9: 200-watt Solar Panel generation with 50% and 75% factors for Sotkamo Kuolaniemi in Monthly Watt hours

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.79	3.93	2.62	2018	Jan	0.87	4.33	2.89
	Feb	2.87	14.36	9.57		Feb	8.28	41.42	27.61
	Mar	11.75	58.77	39.18		Mar	11.33	56.65	37.77
	Apr	10.89	54.44	36.30		Apr	17.09	85.45	56.97
	May	14.09	70.46	46.98		May	29.08	145.40	96.93
	Jun	16.08	80.38	53.59		Jun	19.20	96.00	64.00
	Jul	13.78	68.88	45.92		Jul	31.69	158.47	105.65
	Aug	22.55	112.77	75.18		Aug	18.30	91.50	61.00
	Sep	10.13	50.63	33.75		Sep	10.45	52.26	34.84
	Oct	6.02	30.11	20.07		Oct	6.36	31.82	21.21
	Nov	1.17	5.87	3.91		Nov	1.02	5.12	3.41
	Dec	0.08	0.40	0.27		Dec	0.00	0.00	0.00

Table 10: 400-watt Solar Panel generation with 50% and 75% factors for Sotkamo Kuolaniemi in Monthly Watt hours

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.07	0.21	0.14	2018	Jan	5.69	17.77	11.84
	Feb	3.84	12.00	8.00		Feb	11.29	35.27	23.52
	Mar	12.11	37.84	25.23		Mar	13.38	41.82	27.88
	Apr	11.93	37.28	24.86		Apr	15.69	49.05	32.70
	May	10.71	33.48	22.32		May	25.50	79.68	53.12
	Jun	18.68	58.38	38.92		Jun	16.88	52.73	35.16
	Jul	9.73	30.41	20.27		Jul	31.34	97.93	65.29
	Aug	18.44	57.63	38.42		Aug	15.61	48.77	32.51
	Sep	8.54	26.69	17.80		Sep	10.26	32.07	21.38
	Oct	8.47	26.46	17.64		Oct	7.80	24.36	16.24
	Nov	1.26	3.95	2.63		Nov	0.69	2.15	1.43
	Dec	0.00	0.00	0.00		Dec	0.00	0.00	0.00

Table 11: 200-watt Solar Panel generation with 50% and 75% factors for Rovniemi Lentosema in Monthly Watt hours

Year	M	Dur.	75 %	50 %	Year	M	Dur.	75 %	50 %
2015	Jan	0.07	0.34	0.22	2018	Jan	5.69	28.43	18.95
	Feb	3.84	19.20	12.80		Feb	11.29	56.44	37.62
	Mar	12.11	60.55	40.37		Mar	13.38	66.91	44.61
	Apr	11.93	59.65	39.77		Apr	15.69	78.47	52.31
	May	10.71	53.56	35.71		May	25.50	127.49	84.99
	Jun	18.68	93.40	62.27		Jun	16.88	84.38	56.25
	Jul	9.73	48.66	32.44		Jul	31.34	156.69	104.46
	Aug	18.44	92.20	61.47		Aug	15.61	78.03	52.02
	Sep	8.54	42.71	28.47		Sep	10.26	51.32	34.21
	Oct	8.47	42.34	28.23		Oct	7.80	38.98	25.99
	Nov	1.26	6.32	4.21		Nov	0.69	3.44	2.29
	Dec	0.00	0.00	0.00		Dec	0.00	0.00	0.00

Table 12: 400-watt Solar Panel generation with 50% and 75% factors for Rovniemi Lentosema in Monthly Watt hours